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BATTERY INFORMATION: PERSONALIZING THIS EMERGING RESOURCE

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Technical Report AFAPL-TR-69-40

May 1969

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Air Force Aero Propulsion Laboratory  
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**BATTERY INFORMATION: PERSONALIZING THIS EMERGING RESOURCE**

D. M. Johnson, John McCallum, and G. H. Miller

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## **FOREWORD**

This report describes work performed at Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio, under Contract AF 33(615)-3701. The Budget Program Sequence No. is 6(638173 62405212), and the Task No. is 314522, Project No. 3145, AF Aero Propulsion Laboratory, G. H. Miller/APIP-1, June 30, 1966 - May 1, 1969.

Many persons have helped either directly or indirectly with the preparation of this report. Those attending the work session described in Appendix I of this report are the main contributors. They were: Dr. E. W. Brooman, Mr. R. L. Darby, Dr. C. L. Faust, Dr. R. W. Hardy, Mr. O. L. Linebrink, Dr. J. McCallum, and Mr. D. E. Semones of Battelle-Columbus, Mr. P. W. Cover and Mr. E. A. Roeger, Jr., of Battelle-APL, and Mr. R. A. Marsh and Mr. G. H. Miller of the Aero Propulsion Laboratory. Others subsequently giving aid to this report include Mr. W. S. Bishop, Mr. J. E. Cooper, and Dr. J. J. Lander of the Aero Propulsion Laboratory, Mr. H. B. Thompson of the Air Force Materials Laboratory, Dr. R. J. Brodd of Union Carbide Corporation, Dr. A. Fleischer, Consultant, Mr. John H. Waite, Consultant, and Mr. G. H. Beatty, Mr. W. D. Penniman, Dr. A. H. Reed, Mr. G. R. Schaer, and Dr. T. H. Tidwell of Battelle-Columbus.

The report was submitted by the authors in April 1969.

This technical report has been reviewed and is approved.

CURTIS KELLY, Chief  
Energy Conversion Branch  
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## ABSTRACT

A workable information system has been developed by technical men sharing an interest in the investigation of failure mechanisms of sealed spacecraft batteries. Personal involvement with subject indexing activities resulted in a high level of user interest throughout the program. Engineer support was found to be vital for the operation of an effective information system. A modified system is proposed to serve the future information needs of a larger group of battery technologists dealing with larger amounts of battery information through the use of personalized microfiche based on a central data base.

## PREFACE

Various contractual requirements of the Research Contract AF 33(615)-3701 start with phrases of the following kinds:

"Provide an understanding of the failure mechanisms---"

"Conduct a literature survey to find the areas of inadequate nickel-cadmium and silver-zinc technology----"

"Conduct a review of previous failure analysis technique and results---"

"Investigate the known failure modes----".

Such phrases demand a familiarity with existing knowledge. They suggest the workers will know how to use the information placed before them. Moreover, because nearly 3 years of research are provided by the contract, the phrases must be interpreted to mean that the workers will have access to relevant new information as it becomes available and that the relevancy will be recognized when it exists.

This report describes the encounters of one group of individuals with a large amount of available information. The complexities of information problems were recognized early. Many thorough and distinguished studies of information made it clear that the writers of this report were not authorities or experts in the broad subject of information handling.<sup>(1,2,3,4)</sup> Nevertheless, an analogy is believed to exist with the truism that one does not need to be an authority on the subject of transportation in order to travel. Moreover, one who travels will learn a few tricks for avoiding transportation problems and he will learn some of the limitations and drawbacks of existing transportation methods. He should, in the process of traveling, come up with some ideas for changing and improving transportation. Such is the nature of this report. It describes preliminary considerations about making trips into information about batteries. It describes some of the arrangements made and some of the travel experiences. Finally, ideas for improving specific excursions into printed information are presented for future development.

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BATTERY INFORMATION: PERSONALIZING THIS EMERGING RESOURCE

by

D. M. Johnson, J. McCallum, and G. H. Miller

INTRODUCTION

Much of the vast reserve of electrochemical knowledge developed throughout the years can be found in the published literature from around the world. This reserve of knowledge offers insights and/or solutions to problems. However, it is becoming an increasingly larger chore for today's researcher to maintain an awareness of approximately 170 years of battery technology, much less be able to effectively use the information. The yearly average number of published battery abstracts has changed from about 80 in 1907 to over 500 in 1966. The result is at least 20,000 references specifically referring to the science and technology of batteries. Additional peripheral information is needed by those doing battery research. A workable system is needed for selecting, reviewing, categorizing, and storing pertinent information from the multiplicity of documents. Such a system would be a tool for capitalizing on a valuable and contributing resource, namely the published literature.

## PART ONE

### THE BATTERY INFORMATION INDEX

#### Objectives

The Battery Information Index was conceptually formed in July 1966 to meet the information requirements of Contract 3701. This index was to serve the needs of approximately ten technical persons having varied technical backgrounds and assigned to particular research tasks under this contract. A special need was to supply information services to project members located at Wright-Patterson Air Force Base, Dayton, Ohio, and Battelle Memorial Institute, Columbus, Ohio, approximately 70 miles apart. This need imposed unique requirements for both handling battery documents and keeping all members of the project aware of the latest available information. The following expected features of the Index offered some guidelines for the design of the system:

- (1) Individual preferences would require a versatile review procedure.
- (2) Different personnel would have different review interests.
- (3) Any one individual's interest in information will change as work proceeds.
- (4) Plans for following literature must be adjustable to a wide variety of individual needs.
- (5) The more battery information is used, the more easily an information specialist could answer queries and select useful additions to the Index.

Also recognized during the formulation of the Index was the goal of any information system, namely, "to provide the right information to the right person, in the right form, at the right time, and at his work station".

This goal and the expected features dictated that the Index should have qualities of personalized and flexible procedures for handling and reviewing published battery information.

#### Early Information Activities

#### Planned Procedures

The planned procedures for the initial information operation consisted of the following steps:

- (1) An accession list would be prepared to itemize and number the reports and publications of interest to the Index.

- (2) An abstract card file would be maintained at both Wright-Patterson Air Force Base, Dayton, Ohio, and Battelle's Columbus Laboratories.
- (3) A comprehensive index (subject, author, facility, Government report numbers, and patent numbers) would be prepared. An information specialist would provide the main indexing under the technical supervision of an experienced technical team knowledgeable in all phases of battery technology.
- (4) Project members would have access to the indices by several methods:
  - (a) A complete index would be maintained at Battelle's Columbus Laboratories.
  - (b) Selected indices would be issued to and retained by members identifying special areas of interest.
  - (c) New indices would be compiled for members on any subject that becomes part of the research program.

#### Starting Information Sources

A collection of 260 battery documents was available at the start of the contract. These documents were reviewed for pertinency to the specific items of Contract AF 33(615)-3701. Searches were made for battery information from the following sources:

- (1) Project briefs of the Electrochemical Group of the Power Information Center, Interagency Advanced Power Group
- (2) U. S. Government reports
- (3) Patents
- (4) Open literature.

Typical of the response from searches on U. S. Government reports was the Defense Documentation Center (DDC) machine search under the descriptive "nickel-cadmium and silver-zinc storage batteries" that yielded 664 abstracts. Approximately 400 of these abstracts were rejected during a preliminary scanning by an information specialist as being of an obviously nonpertinent nature to this project. From the remaining 264 abstracts, 114 subsequently were rejected by the technical staff and 38 were entered into the battery file on an "abstract only" basis (indicating a fringe-area interest). Reports for the final 112 abstracts were ordered and entered into the Index, thus indicating that 20 percent of the abstracts in this particular search were useful for this project. Similar statistics were found for the machine searches from NASA. These searches indicate that substantial improvements in locating pertinent documents would be desirable.

## Characterization of Battery Information Index Users

This project offered a rare opportunity to work with literature in several ways and to experiment with old and new methods. An opportunity existed because it brought together a small group of technical specialists with diverse interests and open minds as to how to start anew in an old technology.

The project members proceeded to apply the literature to their work tasks. The technique of reviewing the literature against a list of prepared questions was considered. In this technique, the literature is approached from the standpoint of finding answers to existing questions. Questions appearing unanswered in the literature would be grouped, if possible, to help define the voids and inadequacies.

Various techniques for reviewing the literature were discussed during a special joint work session on battery literature held on February 21, 1967, at Battelle's Columbus Laboratories. This work session was undertaken for the prime purpose of finding the voids and inadequacies in the literature on nickel-cadmium and silver-zinc battery technologies. It also was to be the first step toward organizing work with battery literature. Supplemental discussions at the work session concerned organization and basic principles of information systems and information science. The most significant results and observations of the work session are given in the following paragraphs. A separate report will be issued on voids and inadequacies in the battery literature.

The appended transcript of the work session is considered to be a rather unique document in itself. It represents an actual recording of the reactions of technical men toward information. Many detailed studies have been made by information experts on system designs and operation procedures all based on summaries of user's needs obtained through questionnaires, interviews, diaries, etc. However, very few studies have been based on the direct observation of engineer behavior as related to informational needs. For this reason, the work session will be used as the raw data on which this report is based or the vehicle by which trips for information about batteries were planned, made, and herein described.

At the work session described in Appendix I, an attempt was made to understand the complex relationship that exists between a research project member and his information. As expected, each member was found to have his own preferred way of handling information. What is information to one man was found to be of little or no value to another man working on a related problem. Thus, the 11 technical men participating in the work session were asked to list their own methods for keeping aware of technical developments within individual areas of interest. They responded with 34 approaches, which are listed in Table I.

These responses are listed precisely as reported during the work session. Some appear to be similar, and yet they may be different. For example, "6. Review journals in main library" and "10. Review circulated technical journals", might mean that both individuals scan journals regularly as part of their normal schedules, or the phrases might mean that one man reviews journals only if they are circulated to him or that the other man may visit the library only when he has an information problem. These differences are important when a third party tries to help these persons with their information problems.

TABLE I. SOURCES LISTED FOR KEEPING AWARE OF DEVELOPMENTS  
WITHIN INDIVIDUAL AREAS OF INTEREST\*

- 
1. Rely on others
  2. General discussion
  3. Write a paper or report
  4. Card file on books
  5. Battery accessions list
  6. Review journals in main library
  7. Main library, "New Books" accessions sheet
  8. Chemical Abstracts
  9. Machine-literature searches from Government agencies
  10. Review circulated technical journals
  11. Review patents
  12. "Brain-picking" consultants, fellow workers, competitors
  13. Technical meetings
  14. Salesmen
  15. Trade shows
  16. Destructive analysis
  17. Maintain card file of abstracts
  18. Review abstracts
  19. Use services provided by an information facility (STINFO, WPAFB)
  20. Personal subscription to technical journals
  21. Fuel Cell Information Index at Battelle
  22. Battery Information Index at Battelle
  23. Instrumentation Files at Battelle
  24. Manufacturers' literature
  25. Follow work of researchers in the field
  26. Transactions of technical groups (IEEE, Chem. Soc., SAE, etc.)
  27. Technical Accession List prepared by WPAFB
  28. Abstract bulletins distributed by Government agencies
  29. Don't have a good method
  30. Information Research Centers at Battelle
  31. Newsletters
  32. Commerce Business Daily
  33. Project briefs from Power Information Center
  34. Engineer conferences
- 

\*These methods were submitted by technical personnel listed at the beginning of Appendix I in response to a question posed at Item 1 in Exhibit 2; namely, "Describe your methods for keeping aware of developments within your own field of interest".

Notice in Table I that "12. Brain-picking consultants, fellow workers, competitors", "2. General discussion", and "1. Rely on others" may all be similar but not identical activities. Thus, discussions may be scheduled for the prime purpose of obtaining information about a specific subject. Then, the results of the discussions can be measured by whether or not the desired information was obtained. On the other hand, information may be obtained less directly through informal discussions. In any event, personal contacts are believed to be the most prevalent method for keeping up with what is new. Partly because of this strong preference to ask other individuals, there seems to be a tendency to limit the extent of personal information systems.

The effectiveness of many personal information systems decreases in direct proportion to their growth, as most personal systems become too expensive in time or money and they are eventually abandoned. This fact was recognized early in the program and is mentioned on page A-12 of Appendix I. The format of the Battery Information Index was designed to provide assistance in the personal development of a workable information system by allowing engineers to remove material as well as to add it as their personal interests change.

Other items in Table I such as "13. Technical meeting", "14. Salesmen", "15. Trade shows", "25. Follow work of researchers in the field", and "34. Engineer conferences" give further evidence of the informality of an individual's methods. They also help little with the objective of providing a general method by which individuals can find specific information in the formal body of printed literature.

It may be true that some of the listed methods may be ambiguous. It may even be stretching a point to include "29. Don't have a good method" as a method for keeping aware of the published information on batteries. However, these responses provide a clue to the variety of attitudes on information services within this small group. They emphasize the personal and subjective nature of dealing with information. Hindsight shows us that the responses in Table I could have predicted that a fertile environment existed early in the project for the successful development of a workable information system. Many of the technical men were already aware of the existing need for an information operation. Several had even started their own files. Moreover, the participants in the work session expressed willingness to contribute toward the development of the system for this project.

#### General Principles of Information Science

Battelle's Columbus Laboratories have been concerned with large-scale information operations for approximately 20 years. A number of practical concepts about the users of information and their information systems were established(5,6,7,8,9,10,11). This background experience shows in Appendix I, pages A-2 through A-44. Moreover, there are a number of basic principles throughout Appendix I that probably would appear in any similar work session about technical information. These fundamentals will be briefly discussed as questions.

#### Who Needs Information Assistance?

Information experts have found at least two kinds of technical men who feel they have no information problem. First are those individuals who are top scientists in their

fields. They know and communicate, for the most part, with other experts - and it is quite true that they do not have an information problem for reasons explained on pages A-10 and A-11 of Appendix I. However, technologists at the working level must communicate with a larger audience of peers than the top scientist and always seem to have information problems.

This communication between top scientists constitutes, in part, a participation in the "invisible college" described briefly below.

The concept of the invisible college originated around the year 1650 as an attempt by the scientists of that time to cope with a flood of literature appearing on the scientific scene. The concept flourished during World War II due to widespread teamwork projects. The purpose of the invisible college was to substitute personal contact for formal communications among persons making important contributions to their fields.<sup>(12)</sup> Some information experts<sup>(13)</sup> are of the opinion that, in fast-moving technologies, personal contact through the invisible college is not only the most prevalent method of keeping aware of technological developments - it is the most important. Other information people<sup>(3)</sup> feel that, while the existence of the invisible college should not be ignored in a consideration of information science, certain disadvantages of the technique should be recognized. For example, these groups of experts have come under a certain amount of criticism during recent years<sup>(3)</sup> as being rather elite and unaccessible to young scientists. It is felt by some observers that the progress of younger scientists may be hampered unless they happen to be within the group of recognized experts or are accepted by the group and are invited to informal meetings and/or formal conferences.

Attendance at technical meetings is generally believed to be an important part of a researcher's work. The format of technical conferences has gradually changed over the years to allow for increased participation for more scientists and for wider audiences. Thus, communication through the invisible college, while effective to a considerable extent, has evolved into a multiplicity of scheduled technical meetings around the world. In the field of engineering in the United States there were reported<sup>(3)</sup> to be an average of three meetings per day for each day of the year. A possible technique was proposed<sup>(3)</sup> by which scientists could receive the benefits of meeting attendance without the involved travelling through the use of a national communication network by which a scientist might be able to "plug in" to the invisible college.

A second group that seldom admits to having an information problem is made up of the managers or directors of large numbers of technical personnel. Presidents of companies and monitors of large Government contracts are also part of the same top-management group that knows each is only one or two telephone calls away from the experts. Such persons merely pass an information problem down through the chain of command to the "Jim Smith" depicted on page A-15 of Appendix I.

In summary, then, the vast majority of research workers need information assistance. Any future battery information system should be aimed at the working level of research, development, and engineering rather than to the management of such workers.

#### What Is Useful Information?

As noted on page A-9 of Appendix I, "What is information to one man may be of little or no value to another man working on a similar problem."

Also, on page A-11, "these men at the working level are not concerned with fancy information systems. The only thing they are concerned about is to receive the information or data at the time they need it. If it is received a week later, it's useless. It's also relatively useless if it comes to their attention a week early---".

At other places in Appendix I, the usefulness of information is relative, as when questions are asked for on pages A-7, A-8, A-32, and A-60 or as when the total context of published information is referred to on page A-31.

The net result is that the usefulness of information is a personal decision. Any future battery information system should take into account this personal relationship. Engineer conferences with an information specialist are believed to be essential if the information specialist is to become a link between an engineer and a large information system.

#### How Does a Technical Man Retrieve Needed Information?

Information experts have learned through experience that when an information problem arises, the technical man usually checks his memory and personal files first. Then he talks to another technical man, who may recommend that he contact still another technical man. It is noted on page A-15 of Appendix I that a library or information system is usually the last place to be contacted by the technologist. For this reason an information system should be taken to the man, if possible, rather than trying to force the man to come to a system. Any future battery information system should decentralize its services so that each man can personally retrieve his own information.

#### When Is Information Needed?

The figure on page A-19 of Appendix I illustrates the two main circumstances when engineers want information. The first circumstance is illustrated by the lower "new interest problem area", which is separated from the traditional work of the research worker. These new interests occur when any man starts new effort on a subject new to him. Under such a circumstance, that man generally wants anything you can give him.

A second circumstance for wanting information occurs with the upper branching "new interest problem area". On page A-19, these branches are connected with the worker's traditional effort. As such side issues come up during a research project, the technologist will want information pertaining to these side issues. The information need is then specific because the worker knows almost exactly what it is he wants. However, because neither the subject matter nor the duration of these "new interest problem areas" can be predicted, the contents of any future battery information system must be easily changed.

Also, even though time limits are difficult to set up as to when information should be delivered in response to a request, most engineers for all practical purposes will want to receive information when they need it - not too soon nor too late.

### Where Is Information Needed?

The geographical location of an information operation can be an important factor in regard to the usage of information. If the system is located at some distance from the user's desk or laboratory, a certain amount of planning may be required to visit the facility. If the user has a particularly busy schedule, he possibly may decide to visit the file at a "more convenient time". The result may be that the "more convenient time" never presents itself, the need for information may somehow be resolved, and then the opportunity to serve a prospective user has been lost. It is therefore believed that information should be provided whenever it is to be used.

### Problems With Reviewing or Using the Literature

#### Questions Before or After Reading Literature?

As expected, the reviewing or using of literature was found to be subjective at the work session. Thus, each person had his own ideas about how to proceed, but two categories of problems apparently occur to everyone. There is, first of all, a question of what to do with the information appearing as part of the published literature. Thus, new reports and papers appear regularly, and technical people should ask questions about that literature such as:

- Does this new report contain information that will help me in my own work?
- If it is not needed now, will the information be needed later?
- If it is needed later, how can I file it so that I can retrieve it?
- Are new ideas or concepts coming forth that I should know about?
- Is there new information of interest to others on the same project?

There is no limit to the questions one might ask as a result of the growing backlog of documents about batteries.

A second but similar general problem arises when one starts with a question. Then he wonders what information is in the literature that might answer the question:

- How much electrolyte is in a sealed cell?
- What are separators made of?
- What causes loss of capacity with deep cycling of a battery?
- How is temperature related to failure mechanisms?

There is no limit to the specific or general questions that one can have in mind as he turns to the literature to find answers.

This distinction between reviewing literature first and then asking questions as opposed to asking questions first and then reviewing the literature is pivotal. Some persons seem not to know how to read first and ask later. Such persons require a question in mind first before they can tell whether there is an answer. Other persons seem not to know how to find an answer in the huge information haystack even when asking a specific, needling question. Most persons are at neither extreme but tend to prefer either the question first or the information first, and they become largely subjective in either event.

#### Standardized or Nonregulated Terms?

One of the discussions held during the work session was concerned with a dilemma over standardized terms. It was pointed out on pages A-9, A-10, A-29, A-30, and A-36 that a researcher wants the freedom of expressing different things differently on the one hand, but he also wants to be understood and wants others to gain from his work. With his desire for freedom of expression, he may coin new words or give new meanings to old words, with the adverse effect that someone may not understand him. This dilemma on standardized terms is also apparent in subject indexes. There may be five or ten terms that a researcher could use to describe the same thing. For example, the "oxygen-consuming electrode" may be called a "third electrode", "auxiliary electrode", "Adhydrode", or a "charge-control device". The problem of indexing involves a decision as to which entry will produce the desired information on the "oxygen-consuming electrode".

A suggestion was made at the work session to publish a survey with coined words in an attempt to encourage battery manufacturers to use standard terminology. It was thought this plan might be similar to a system established by lawyers wherein each word or phrase has a specific meaning decided by court tests. The engineer reactions on pages A-29 and A-30 emphasize a general principle of information science, namely, that each information system should be designed primarily for the people who use it. Lawyers use a technique that works for them, and it appears that a workable information system for battery technologists may find its roots in the procedures being developed for the engineers doing battery research.

It also was pointed out at the work session that the apparent lack of standardized technical language is not unique to the battery industry. Many scientific disciplines appear to have experienced similar voids. On the other hand, some technical areas appear to have made considerable progress in obtaining vocabulary control. Information people have been successful in developing methods for handling synonyms and antonyms as well as hierarchical relationships of terms for specific technological areas. (14-17) However, for this particular battery program, one technical man felt that, while it might help users of the Battery Information Index to get an idea of what to look for, a thesaurus might not be the complete solution. It might be difficult to set up a fixed vocabulary using report sources that do not contain words with well-defined meanings. It appears that the development of a dictionary of battery terms, together with a thesaurus, might be of considerable assistance to battery technologists.

## User-Oriented Operation and Maintenance of a Battery Information Index

The expressions by the project members during the work session about their dealings with information were valuable. Their expressions confirmed the original expectations - that working with literature is a personal and subjective process and that information services should be designed for the persons using it. Their expressions also offered guidance for continued development of the Battery Information Index by clearly showing the project members that their participation in structuring and operating the Index was essential. Also, users were found to exhibit a consensus for certain preferences, which will be described in paragraphs to follow.

### Phrases Versus Single Words

Regarding preferences, the project members pointed out several shortcomings of the original format of the Index, namely,

- (1) Large numbers of references accumulated for a given index entry. A need existed to index the subject matter so that engineers would scan only a minimum number of documents.
- (2) Comments from Index users indicating that as much as 15 minutes per search was being spent in scanning the subject index. A need existed to index in ways to shorten scan times.
- (3) Not all searches for prepared indexes had been successful. A need for a more comprehensive subject index was apparent.

These shortcomings led to proposed revisions of the Index. The first revision enacted was to have participating members use word phrases rather than single-word descriptors. The decision to use multiple-word rather than single-word descriptors was made on a suggestion made during the work session. Whereas single-word terms may be easily adaptable to computer operations, may simplify indexing procedures, and may even reduce false retrievals, it appears that key-word phrases provide for deeper indexing and eliminate development of general categories with large numbers of references.

The use of key-word phrases has several other advantages:

- (1) Research personnel have a tendency to use phrases. Therefore, the task of assigning descriptive terms is not as big a burden as their being asked to limit word choices to single terms. Indexing practices of battery technologists exemplify distinctive information needs, as the majority of approved subject terms were highly specific in nature. For example, the term "nickel oxide electrodes, mechanism for loss of charge" was approved by a technical man who possibly expects to use that entry at some future time. He has reasoned that a single term such as "electrodes" could slow down the retrieval of needed information because of the large number of references possibly associated with that entry. An information user has indexed a document in the way he expects to retrieve it.

- (2) Phrases provide a mechanism to reduce the number of references for individual subject entries, because subtitles may be added when desired.
- (3) Phrases may produce an index similar to the indexes most battery engineers are accustomed to using, such as Chemical Abstracts.
- (4) Use of phrases may be helpful to engineers using the Index for the first time, as no organizational instructions are required. For example, some systems necessitate usage of supplemental tools such as retrieval guides, which imply "--if you want information on this subject you must use that word--".
- (5) Key-word phrases may reduce the number of questions in the minds of file users as to how certain terms were chosen or in what context they are used. For example, "separators, sterilization resistance" is probably more helpful to a user of an index than "separators", because less effort is required to locate the information which might be pertinent to the question in mind.
- (6) A listing of key-word phrases may lend itself to the establishment and usage of a common set of terms and identification of a common reserve of knowledge, which may lead, perhaps, to a group of terms for the engineers working on this or similar projects that become standardized by usage rather than by regulation.

A sample page from the October 1958 quarterly subject index of the Battery Information Index is included as Figure 1. Each of the terms listed throughout the subject index has been approved by a battery engineer. This page constitutes evidence that phrases are preferred over single words (1) for minimizing the number of documents per entry in the index, (2) for shortening scan times, and (3) for increasing the comprehensiveness of subjects indexed.

#### The This-Month-At-A Glance (TMAG) Experiment

The procedures for obtaining technical approval of phrases on a continuing schedule developed from the following experiment:

Supplements entitled "Suggested This Month-At-A-Glance" and "Revised This Month-At-A-Glance" were distributed with the Battery Information Index Monthly Accession Lists. These supplements consisted of abbreviated statements containing B-Numbers, facility names, and selected key-word phrases to describe the subject content of each document. The "Suggested TMAG" contained key-word phrases suggested by an information specialist. Each technical man was assigned specific documents for evaluation. Individual conferences were held during each month for the purpose of discussing the suggested subject terms and other aspects of the Index. During the conferences, either the terms were approved, modified, or rejected or alternate terms were added.

C

- Cadmium electrode, heavy (0.085 in.); 1067  
Cadmium electrodes, organic electrolytes; 981, 982, 1022  
Cadmium electrodes, preparation; 1110  
Cadmium electrodes, preparation of, arsenic additions; 1061  
Cadmium-oxygen cells, development of; 1067  
Calcium electrodes, in organic electrolytes; 1030, 1091  
Calcium hydroxide film separator, effects of quality; 1109  
Calcium hydroxide film separator, electrodeposited; 1109  
Calcium hydroxide film separator, presence of electrolyte in pores; 1109  
Calcium, reaction with organic solvents; 1107  
Calcium, stability in organic electrolytes containing sulfur; 1111  
Calorimeter, design; 1136  
Calorimetry, lithium-copper fluoride cells; 986, 990  
Calorimetry, Ni-Cd cells; 1108  
Calorimetry, nickel-cadmium cells, bibliography; 1136  
Capacity, effect of periodic current; 1144, 1145, 1146  
Capacity gain, nickel electrodes; 1058  
Capacity loss in sterilized cells; 1051  
Capacity test measurement techniques; 1101  
Carbon content, electrodes, organic cells; 1081  
Cathodization experiments, organic electrolytes; 1003  
Cell reversal, prevention of; 1062  
Ceramic seals; 1150  
Charge cut-off studies; 1099  
Charging, effect of periodic current; 1144, 1145, 1146  
Charging electrode; 1067  
Chlorides, electrodes for high temperature batteries; 1076  
Chlorine adsorption on charcoal; 1004  
Chlorine electrodes, performance; 1005  
Chlorine electrodes, polarization; 1004, 1018, 1034, 1082, 1083  
Chlorine electrodes, preparation; 1004  
Chlorine, gas analysis; 1005  
Chlorine, reaction with propylene carbonate; 1107  
Chloride solutes; 1131  
Chromatography, analysis of organic solvents; 983, 984, 995, 1019, 1023, 1132  
Chromic oxide electrodes in organic electrolytes; 1016  
Chromium electrodes, in organic electrolytes; 982  
Chromium oxide electrodes, polarization; 1133  
Chronopotentiometry in organic electrolytes, reproducibility; 1019  
Cobalt additions to nickel; 1059, 1140  
Cobalt chloride electrodes, in organic electrolytes; 980  
Cobalt electrodes, in organic electrolytes; 979, 980, 1001  
Cobalt fluoride electrodes; 986  
Cobalt fluoride electrodes in organic electrolytes; 1103  
Cobalt fluoride electrodes polarization; 992  
Cobalt fluoride electrodes, voltammetry tests; 990  
Cobalt fluoride electrodes, X-ray examination; 1002  
Cobalt fluoride, solubility in organic solvents; 1002  
Cobalt oxide electrodes, in organic electrolytes; 979

FIGURE 1. SAMPLE PAGE OF THE SUBJECT INDEX OF THE BATTERY INFORMATION INDEX FOR OCTOBER, 1968

Figure 2 shows a sample page of a TMAG used for engineer conferences during March 1968. It can be seen that battery researchers were quite specific in their retrieval preferences. In B-864, the suggested phrase "electrolyte depletion" was considered to be too general, with the result that the phrase was modified to read "electrolyte loss in fuel cells". Also, "purging operation in fuel cells" in B-864 was modified by the technical man to read "fuel cells, purging operation". This latter modification indicates two technical preferences: (1) the engineer wants to retrieve information relating to the purging of fuel cells under the object being acted upon rather than information relating to the action itself and (2) the technical man has recognized a need for consistency in presenting key-word phrases and has taken upon himself a share of the responsibility to see that such consistencies are perpetuated. Examples of key-word phrases completely rejected by the technical men can be seen in both B-861 and B-864. Such phrases as "nickel electrodes, foil", "nickel electrodes, plate", etc., were not wanted in any form for these particular documents.

Upon completion of the engineer conferences, the corrected "Suggested TMAG" was reissued as the "Revised This-Month-At-A-Glance" Supplement. The approved subject terms were added to the subject index.

The "This-Month-At-A-Glance" experiment has been successful as a tool for developing the engineer-approved subject index and is being continued. The "Revised TMAG" Supplement was discontinued, because the approved changes are incorporated in subsequent indexes without the extra paperwork.

#### Individual Conferences

Conferences were originally scheduled for the purpose of obtaining technical approval of key-word phrases on the "Suggested This-Month-At-A-Glance" Supplement. An additional bonus was derived from the conferences in the form of suggestions about using battery information. Technical men offered practical suggestions for improving the system, with the result that many of their ideas were incorporated in the basic document-handling procedures. Such engineer involvement has created considerable engineer interest in information services and has helped to establish a personal relationship between engineers and their information resources. Thus, the "This-Month-At-A-Glance" experiment has resulted in an information system created by the users of the system.

Questions and Suggestions. Typical of the questions and suggestions obtained from technical men during the series of conferences are the following:

- Question - Should the subject index include references to battery types other than sealed, rechargeable nickel-cadmium and silver oxide-zinc batteries? This question led to a decision to index information about lead-acid, vented nickel-cadmium, primary silver-zinc batteries, etc., only as that information appears in documents about sealed cells. The indexing of it will increase the future possibilities of the Index serving a wide audience.
- Question - Should manufacturers' literature be added to the Index? - A decision was made to include this type of information upon request by the project members because a considerable amount of new information is available only through company brochures and catalogs.

March, 1968

SUGGESTED  
"THIS-MONTH-AT-A-GLANCE"

B-861

John Ferreol Monnot  
British Patent (1924)

- nickel electrodes, disk Coil ✓  
nickel electrodes, foil ✓  
nickel electrodes, plate ✓  
nickel electrodes, ribbon ✓  
CELL DESIGN, Ni-Cd ✓

B-862

Nife Batteries Limited  
British Patent (1944)

- nickel-cadmium battery,  
vented, construction of ✓

OK AS IS

B-863

Victor Herold  
British Patent (1929)

- cadmium electrodes, preparation ✓  
nickel-cadmium batteries,  
construction of ✓ AS  
nickel electrodes, positive  
preparation ✓ IS  
nickel flakes ✓

B-864

Institute of Gas Technology  
Second Quarterly Report (1968)

- electrolyte depletion LOSS IN FUEL CELLS  
failure, fuel cells, causes of ✓  
free convection analysis ✓  
fuel cell performance decay ✓  
fuel cell start up  
heat transfer in electrochemical  
systems ✓  
mass transfer in electrochemical  
systems ✓  
purging operation in fuel cells, ✓  
FUEL CELLS, IMMobilized  
ELECTROLYTE ✓

B-865

Yardney Electric Corporation  
Third Quarterly Report (1968)

- charge cut-off device ✓  
charge pulse ✓  
charge termination circuits ✓  
charging, pulse, apparatus ✓  
polarization studies, zinc  
electrodes ✓  
third electrodes, carbon  
activated ✓  
zinc electrodes, concave ✓  
zinc electrodes, long life ✓  
zinc teflonation ✓

OK AS  
IS

B-866

The Electric Storage Battery Company  
Interim Summary Report (1967)

- absorbers, composition &  
stability ✓ OK  
cell case materials ✓ AS  
cell fabrication ✓ IS  
cell shock analysis ✓  
dissolution of zinc oxide  
into KOH ✓  
electrical conductivities of  
KOH ✓  
gassing of zinc electrodes ✓  
heat sterilizable cell ✓  
impact resistant cell ✓  
performance of sterilized  
sealed cell ✓  
sealing technique ✓  
separator materials ✓  
separator screening method ✓  
silver-cadmium cells ✓  
silver-zinc cells ✓  
solubility of silver oxide in  
KOH ✓  
solubility of zinc oxide in  
KOH ✓  
vapor pressure of KOH ✓  
wicking of absorbers ✓  
x-ray study of electrodes ✓

FIGURE 2. SAMPLE PAGE OF A TMAG SHEET USED IN MARCH, 1968

- Suggestion - It was suggested that extracts for patents should use the most general claim (usually the first claim) plus statements describing prior difficulties with other products or processes. This suggestion was adopted, since it was believed that an extract of this type would be most useful to both technical and nontechnical users of battery information.
- Suggestion - It was suggested that evaluation comments be added to the individual abstracts listed on the Battery Accessions List. Project members have indicated an interest in this suggestion and have expressed a willingness to participate in evaluation activities. A subsequent change in the format of the Battery Accessions List (removal of abstracts) postponed further consideration of this suggestion.

These questions and suggestions demonstrated user reaction through involvement. This type of playback functions as an instrument for recognizing and accommodating user preferences, thus achieving an increased effectiveness in the Battery Information Index.

Personal Rapport. The individual conferences also provided a mechanism for keeping tabs on how well the information system was working. The casual atmosphere of informal discussions allowed an opportunity for both the technologist and the information specialist to express individual preferences and to discuss details of information handling that might be omitted from more formal meetings. Whereas group meetings are most generally used to summarize procedures or plans, the individual conferences afforded an opportunity to learn how the system affected "Jim Smith" - what was the system doing for him? - was he able to locate the information he needed on how to prepare porous battery electrodes? - does "Jim Smith" recommend the system to other technical men as a source of information? - If not, why not? Problems, both major and minor, were presented, discussed, and either dismissed or considered in greater detail at future meetings.

Individual meetings also have served to clarify system procedures and to promote understanding of how new approaches to information handling might be compatible with existing practices. It was learned that considerable time and effort could be saved by using the conferences to establish changes in the operation policies of the Index. Some technical men were quite emphatic in their approval or disapproval at the outset of a new procedure. For instance, it did not take long to learn that the technical men were totally opposed to suggestions for discontinuing the Battery Information Index Accession List and to reevaluating the existing collection of battery documents for purging purposes.

Conference Times. Each individual conference required about 3 hours of the information specialist's time to prepare for the meetings, to attend the conference itself, and to record decisions and ideas resulting from the discussions. Also, the average amount of time spent by each technical member in assisting with the development of the Battery Information Index was estimated to be 2 hours/technical man/month. This effort was found to be sufficient and obtainable without causing conflicts in work schedules. Each of the engineer conferences spanned time periods from 15 to 90 minutes, with an average duration of about 30 minutes. These meetings usually were scheduled once a month at times mutually convenient for both the technical man and the information specialist. Special conferences were held occasionally when desired by the technical

personnel. The individual conferences were found to represent a vital link in the information system and should be continued as the Index grows. The meetings provide both a system of checks and balances for the information operation and a reliable indication of system effectiveness.

#### The Word-Choice Experiment

Discussions between engineers and an information specialist were held on problems associated with approval of subject terms approved by one engineer but later challenged or questioned by another. An experiment was performed involving word choices relating to similar ideas but expressed in different ways. Three engineers were given a listing of 11 sets of similar subject terms. They were asked to indicate those terms they believed to be most useful. This request was made as an attempt to remove possible duplication and to reduce the number of superfluous terms in the approved index. After the "votes" were tabulated, it was learned that five additional terms had been added to the original listing. None had been rejected.

This reaction is thought to be analogous with that of submitting challenged but approved words to a committee and obtaining a lack-of-consensus reply rather than a specific decision. This result indicates that utilization of a committee to determine word choices might easily become a time-consuming activity losing touch with the personal wishes of engineers using the Index. Accordingly, the plan outlined in Figure 3 was proposed, discussed, and adopted as the simplest way to obtain approved index terms. Briefly, the plan allows an engineer to index the subject matter of any document in any way he pleases. At the same time, any subject term may be challenged but can be changed only with the approval of the engineer who originally authorized its entry into the subject index.

Results of Challenging. Early in the program, each technical man was averaging three or four challenged key-word phrases per conference; that is, an average of three or four subject terms that originally had been accepted by a given engineer had been questioned either by another engineer or the information specialist. Challenges from other engineers usually involved a matter of technical usage of given terms, whereas challenges from the information specialist usually concerned choices of word forms to ensure consistency within the growing accepted word list. Modifications of challenged phrases were not always made. When a modification was unacceptable, the technical member issuing a challenge had two options: (1) to withdraw the challenge and/or (2) to enter other key-word phrases into the indexing system. As the project continued, the number of challenged terms gradually decreased. At the present time, it is a rare event to have any terms questioned. It is believed that, as the engineers developed the subject-phrase list, their usage of the Index also increased, thereby increasing the use of the Index as a guide for acceptance of suggested terms. The information specialist also used the accepted word list for preparation of the "Suggested This-Month-At-A-Glance" Supplement.

It was recognized that many technical men will abide with a previously made decision on word choices. As more key-word phrases were added to the accepted list, fewer terms were challenged.

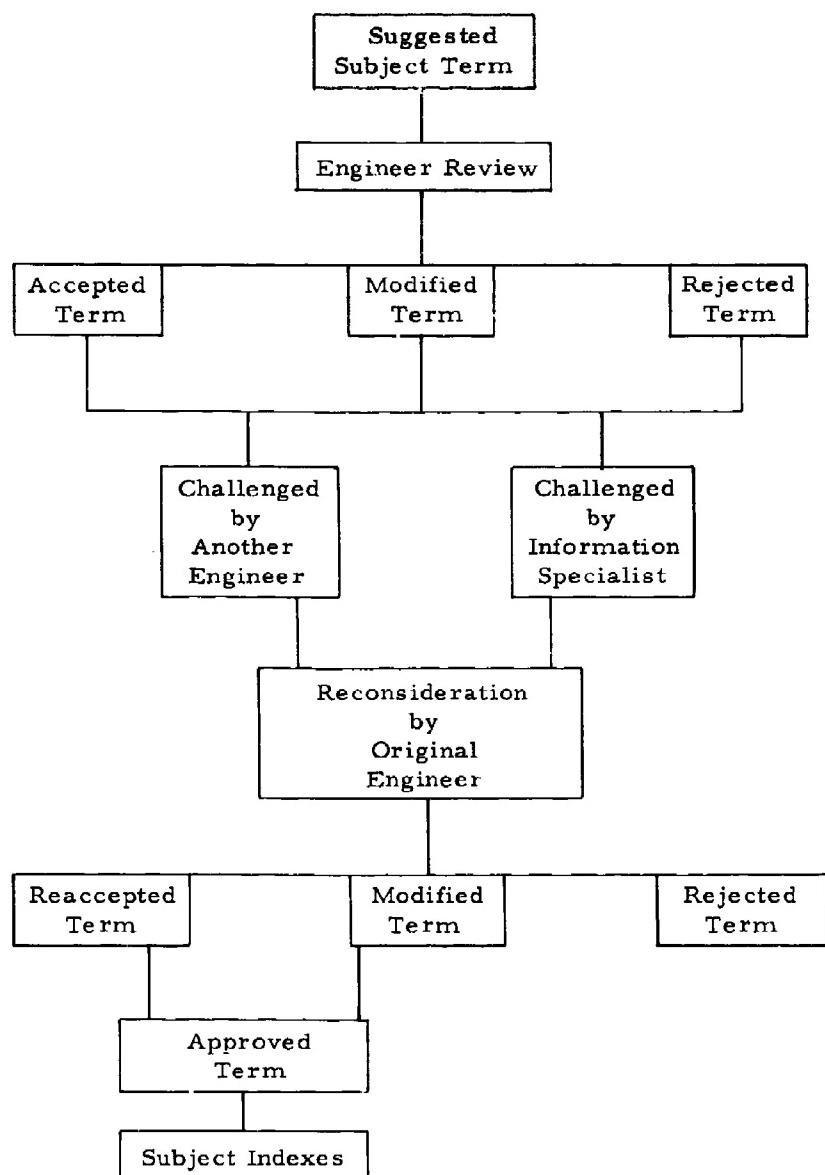


FIGURE 3. A MECHANISM FOR OBTAINING APPROVED INDEXING TERMS BY THOSE WHO WILL USE THE INDEX

## The Indexing Experiment

Amount of Indexing. Statistics were obtained pertaining to the idea "to determine a possible relationship between the number of approved subject terms per document and the apparent value of the battery document" and to answer the questions "How deeply should I index?" and "How many subject terms should be assigned to each document?"

A sample group of 79 consecutive documents (B-548 through B-629) was considered. This group consisted of eight journal articles, eight journal abstracts, one patent, 16 patent abstracts, 40 Government reports, and six Government report abstracts. Relationships were sought between the number of subject terms and (a) document type, (b) document publication date, (c) number of references cited in a document, (d) number of figures and tables presented in a document, and (e) number of pages in a document. Results are summarized herein:

(1) Document Type. On the average, six terms were used to describe journal articles, four terms were used for journal abstracts, four terms were used for patents, three terms were used for patent abstracts, 11 terms were used for Government reports, and four terms were used for Government report abstracts. Moreover, the average number of subject terms used for the entire sample group is six, with an average number of four terms used for abstracts and an average number of seven terms used for complete documents.

Reference to Figure 4 shows that the number of subject terms per document varied considerably. Furthermore, the distribution was not symmetrical. It is noteworthy that, for all documents, the most popular number of subject terms per document was three. This suggests, in many cases, that only a few subject terms may be necessary to describe the contents of a document adequately for engineers using the Index.

(2) Document Publication Date. The age of a document appears to have no bearing on the number of subject terms assigned to it. Depending upon technical needs, an "old" document (over 5 years old) might be of considerable usefulness.

(3) Number of References Cited in a Document. The number of references cited in a document was found to have no relationship to the assigned number of subject terms. That is, documents with lengthy reference lists appear to warrant no more subject terms than do documents with shorter reference lists.

(4) Number of Figures and Tables Presented in a Document. No relationship to the number of subject index terms was found for the number of figures and tables presented in a document.

(5) Number of Pages in a Document. The length of a document was found to have no bearing on the number of subject index terms assigned to it.

As a result of this brief study, the answer to the question "How many subject terms should I assign to each document?" remains simply to be "As few terms as you anticipate necessary to retrieve the document several years from now". However, an average subject index has been found to have six index terms per document. Another principle evolving from this experiment relates to the policy of not distinguishing documents by date of publication. All documents of interest will be included in the Battery Information Index regardless of when they were published.

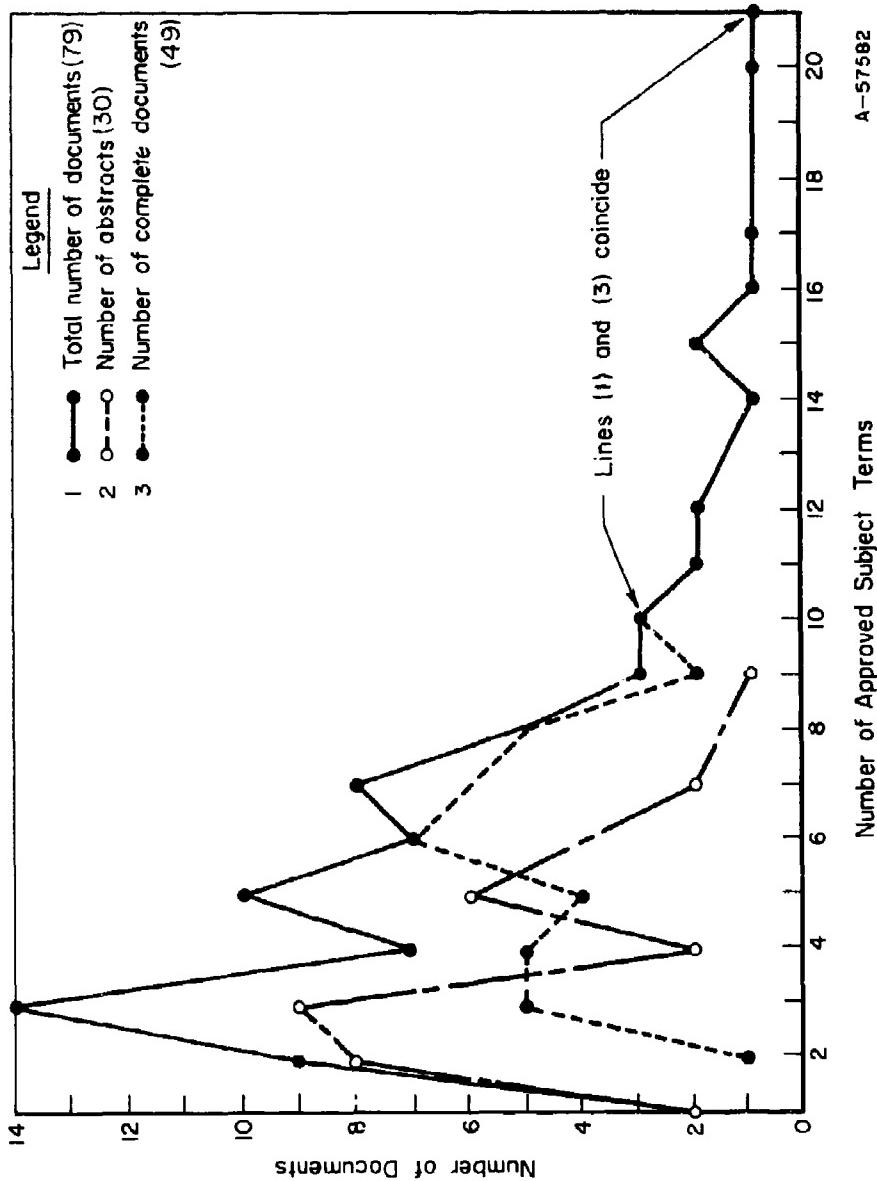


FIGURE 4. RELATIONSHIPS BETWEEN ABSTRACTS, COMPLETE DOCUMENTS, AND NUMBER OF APPROVED SUBJECT TERMS (JULY 1967)

The results of the above indexing experiment were compared with indexing practices of Chemical Abstracts. A sample group of ten journal article abstracts and ten patent abstracts was selected from the Electrochemistry Section (Number 77) of CA, Volume 69, for November 11, 1968. The Keyword Index attached to that publication showed as many as five subject terms and as few as one subject term, with an average of three subject terms per abstract. The number of subject terms per document shown in Figure 4 varied considerably, although the most popular number of subject terms per document was three. However, as noted in (1) Document Type above, the average number of subject terms per journal article was six and per patent was four. Thus, comparison of the two operations, Chemical Abstracts and the Battery Information Index, indicates a general agreement that only a small number of terms are required for indexing a given publication. It appears, on the basis of this very brief comparison, that the Battery Information Index prepared by engineers is providing indexing services comparable to that provided by professional indexors at Chemical Abstracts Service. The results of the experiment may also give some degree of assurance that a technically approved word list as herein described need not be extensive to be effective in retrieval procedures.

Index Preparation. Another aspect of indexing that received consideration dealt with keeping indexes up to date. As noted later, new index pages are circulated to project personnel, quarterly and annually with old index pages then discarded. At first, the information specialist simply retyped a new index; then, as the number of documents increased, this total retyping of indexes became burdensome.

Although there were several available techniques for accomplishing these retyping tasks, the Flexowriter was chosen as a readily available, workable, and economical tool to simplify the preparation of indexes. A list of advantages expected from usage of the Flexowriter is presented below:

- A Flexowriter generates two products: hard copy suitable for reproduction and distribution and a paper punched tape suitable for use in a computer.
- A Flexowriter produces hard copy with both uppercase and lowercase type similar to that of a standard typewriter.
- Indexes may be updated quickly. Additions and/or corrections may be made to an existing index tape; this would result in a new cumulative index.
- Two tapes (for example, a complete index with a quarterly index) may be merged to generate a third tape (a combined accumulated index). No new typing would be involved. The printout time for the Flexowriter is approximately 100 words per minute.
- An automatic printout of a correct tape eliminates the possibility of typographical errors associated with retyping tasks. A substantial amount of proofreading time is saved as well as the greater time saving in complete retyping tasks.

Computer experts worked closely with persons preparing the Flexowriter tapes to ensure that the Flexowriter format would be compatible with computer programs. The Quarterly Index of October 1967 was printed by computer using the Flexowriter tapes to

demonstrate successfully that their preparation could be in conjunction with or without computers.

A listing of the characteristics of computer-produced indexes was provided with the Second Quarterly Index prepared by Flexewriter and is repeated here:

- Alphabetical information can be manipulated in a manner substantially similar to numerical data.
- The utilization of a computer provides an opportunity for storing huge collections of recorded information from which segments may be retrieved quickly.
- A computer can compile and print out portions of an information file such as special bibliographies, accessions lists, and indexes.
- A computerized operation demands standardization of techniques and will highlight errors of inconsistency. For example, material on a computer-produced index is presented in uppercase type. An obvious error might be L35 rather than 135, which is readily reorganized as an error and promptly ignored by the user.
- Computers are highly reliable in performance; that is, duplicate questions should produce duplicate answers.

Contrary to popular belief, automated programs do not necessarily reduce the number of required workers, as a human being is needed to

- Screen the published literature
- Select the documents to be included in the collection
- Index the documents
- Keypunch the index terms that will be stored on tape (or comparable Flexowriter activities)
- Determine the search strategies
- Test and revise the program
- Formulate search questions according to the terms of the stored information
- Enter questions into the machine
- Operate the computer
- Screen and evaluate machine output

Further work will be needed to determine whether a computerized index is worth the costs to be incurred with its use.

A decision to prepare annual indexes by combining quarterly indexes resulted from an effort to reduce their preparation time. Consideration was given to a method for annually adding quarterly listings to a cumulative index rather than issuing complete indexes each quarter. This would (a) shorten the quarterly indexes, thereby reducing preparation time, (b) keep project members aware of the most current information, and (c) provide complete coverage on battery technologies within the project scope, when needed, through the annual plus quarterly indexes.

### The Question Experiment

This experiment involved tentative plans for conferences with technical men to discuss and to clarify questions submitted during the work session on battery literature as described in Exhibit 22, page A-62, of Appendix I. Early in the testing program, some of the questions were discussed briefly with several of the engineers. Most of the questions discussed were of the general type and required considerable rephrasing. For example, Question No. 1 in Exhibit 22, "How to make electrodes?", was discussed from the standpoint of what kind of electrodes were of interest - plate, tubular, porous, plaques, nickel, silver, etc. The question was changed to a statement that read "Send me information relating to the production of nickel electrodes for nickel-cadmium sealed spacecraft batteries". Other questions had lost their timeliness as the engineers moved on to other technical interests. An example of this type of question can be seen in No. 5 - "What is the mechanism of  $\text{Ag}(\text{OH})_2$  decomposition in alkaline solution?". The technical man who asked that question left the project before an answer could be supplied. Other questions appeared to be requests for literature searches: Question 4, "What failure mechanisms are mentioned in the literature?"; or Question 10, "Are there expressions, in equation forms, for describing battery performance and capabilities?". Still other questions required clarification: Question 3, "What units of measure are most commonly used for batteries?". The confusion is aimed at "most commonly used" - by whom? Or, Question 7, "What is an acceptable operational definition of cell failures?" - the problem in this case is "acceptable" - to whom? Or, Question 10, "Are there equations to identify standard units for comparisons among systems but on a normalized basis?" - the problems being "standard" and "normalized". Still other questions appeared to be statements of technical interests rather than direct requests: Question 2, "How to define, detect, and measure failure?"; or Question 8, "May I see any and all reports which have measurement techniques described?". One question appeared to be outside the scope of the proposed information system: Question 11, "Thermal properties - of materials - likely to be used?". During the testing period, a few engineers asked specific questions such as Questions 9, 11, 12, 13, and 14, most of which were answered.

This experience with questions strengthens the belief that an engineer's information needs are highly personal in regard to his immediate work; that his questions require prompt answers; and that answers should be available at convenient locations. Future efforts should be directed toward developing a workable system for soliciting questions from engineers and supplying answers within specified periods of time. Soliciting questions is very important, as it allows tangible evaluation of the effectiveness and responsiveness of the system to the user's needs and preferences.

### The Filing Experiment

This experiment related to the development and maintenance of two abstract-card files at Battelle's Columbus Laboratories and one card file at Wright-Patterson Air Force Base. It was originally planned to add approved subject terms to corresponding abstract cards for each reference in the system. It was also planned that engineers would add key words to abstract cards for early documents (B-1 through B-547) not covered in the engineer conferences at the time these particular documents were used by engineers on the project. This experiment was not accomplished as planned, because engineers preferred to use abstracts as provided on the Accessions Lists, with the result that the card files were not used to any great extent. For this reason, it was decided to allow the card files to go "inactive" but to retain them "as they were" for the remainder of the contract period.

During the latter part of 1968, the subject coverage of the Battery Information Index was expanded to include publications relating to lithium battery technology in addition to documents on nickel-cadmium and silver-zinc cells. A special technique was tested to provide all users with easy access to the total collection of documents by means of complete indexes and to place emphasis on information of greatest interest for each user. This was accomplished by means of special accessions lists of selected references relating to specific interests for both groups of users currently using the Battery Information Index. One group of technical men is interested in information relating primarily to lithium batteries. They are being kept aware of new acquisitions in lithium battery technology by means of selected abstracts distributed as a special type of accessions list. The second group of users prefers to be kept informed on all entries to the Battery Information Index; that is, the total collection of battery information rather than a specific area. This second group of users receives a regular type of Accessions List (references with identifying B-numbers) but no abstracts for their personal work stations. Both groups have access to the total collection through identical indexes. To date, these varying information needs present no operational problems, as the system is sufficiently versatile in design to accommodate different retrieval procedures. It was of interest to know if engineers would accept limited numbers of abstracts, and they have done so. This point may be an important factor in the future development of a system for many users.

At the time lithium documents were added to the system, abstracts were removed from the Accessions Lists. This action resulted in a decision to reactivate the abstract-card file at Wright-Patterson Air Force Base. The present operation is concerned with the development and maintenance of one card file at Battelle's Columbus Laboratories and a second file at Wright-Patterson Air Force Base.

It may be concluded from the Filing Experiment that battery technologists prefer to have abstracts of documents close at hand either on an accessions list located at their desk or in a card file located in the laboratory.

### Present Format of The Battery Information Index

As a result of several experiments, an information system for battery engineers on this project was proposed, tested, modified, and accepted as an effective system by the users of the system.

The format presently used for the operation of the Battery Information Index is outlined below:

- (1) The Battery Information Index Accessions List consist of references with identifying B-numbers. References are selected by engineers based on current interests. Any technical man on the project may enter any or all documents into the system he believes to be helpful. Approximately 60 sources are scanned routinely by the information specialist for information about electrochemical energy. These sources are listed in Table II.
- (2) The preparation and distribution of the "Suggested This-Month-At-A-Glance" Supplement to the Battery Information Index Accessions Lists has been continued. The TMAG's are used for (1) the assignment of documents for evaluation, (2) recording of decisions on key-word phrases at individual conferences, (3) preparation of quarterly subject indexes, and (4) temporary supplements to quarterly subject indexes.
- (3) Conferences with technical men have continued on a regularly scheduled basis. It is believed that these conferences are necessary to the success of the Battery Information Index as discussed in the section of the report entitled "Individual Conferences".
- (4) Abstract card files are maintained at Wright-Patterson Air Force Base and Battelle's Columbus Laboratories.
- (5) Quarterly indexes to battery documents are prepared on Flexowriter tape. These indexes provide access to information associated with authors, facilities, subject areas, contract numbers, patent numbers, and also AD- and N-numbers of Government reports where appropriate.
- (6) Annual indexes to battery documents are prepared from combined quarterly indexes.
- (7) An original document file is located at Battelle's Columbus Laboratories, with loan services available to personnel working on the project. A second document backup file is located at Wright-Patterson Air Force Base. This file was set up and is being maintained by project personnel. The duplicate file is arranged in accordance with the file format at BCL to provide information at work stations.

#### Conclusions

A workable information system has been developed by the technical men working on the battery project. Personal involvement with subject indexing activities stimulated and maintained a high level of user interest throughout the program. Engineer support is vital to the operation of an effective information system.

Work with the Battery Information Index has resulted in the recognition of two aids lacking within the area of battery technology: (1) a dictionary of battery terms and (2) individual procedures adequate to locate, index, and evaluate battery information.

TABLE II. SOURCES SCANNED FOR INFORMATION ABOUT  
ELECTROCHEMICAL ENERGY

- 
- |   |  |
|---|--|
| 1. Astronautics                                     | 39. Science Review   |
| 2. Aviation Week                                    | 40. Bulletin of Inventions (Russian)   |
| 3. Chemical Engineering                             | 41. Soviet Electrochemistry  |
| 4. Chemical Engineering Progress                    | 42. International Chemical Engineering   |
| 5. Fortune  | 43. Kinetics and Catalysis   |
| 6. I & EC   | 44. Journal of the Electrochemical Society   |
| 7. Journal of Electroanalytical<br>Chemistry        | 45. Journal of the Electrochemical Society<br>of Japan   |
| 8. Power Engineering                                | 46. Electrochemical Technology   |
| 9. Scientific American                              | 47. Chemical Abstracts (Electrochemistry<br>Section)   |
| 10. Power   | 48. International Aerospace Abstracts  |
| 11. Business Week                                   | 49. Engineering Index  |
| 12. Canadian Journal of Chemistry                   | 50. Dissertation Abstracts   |
| 13. Hydrocarbon Processing and<br>Petroleum Refiner | 51. U. S. Government Research and Develop-<br>ment Reports (Sections of Biological<br>and Medical Science; Chemistry,<br>Physical; Energy Conversion -<br>Nonpropulsive; Materials; Physics,<br>Solid State; Space Technology) |
| 14. Industrial Chemist                              | 52. Technical Abstract Bulletin (TAB) -<br>Same sections as listed under U. S.<br>Government Research and Development<br>Reports   |
| 15. Chemical Processing                             | 53. Scientific and Technical Aerospace<br>Reports (STAR) (Sections on Auxiliary<br>Systems; Biotechnology; Chemistry; and<br>Materials, Metallic)  |
| 16. Engineer  | 54. Energy Conversion Digest   |
| 17. Industrial Research                             | 55. Advanced Battery Technology  |
| 18. Journal of Physical Chemistry                   | 56. Denki Kagaku Newsletter  |
| 19. New Scientist                                   | 57. Project Briefs from the Power Informa-<br>tion Center, University of Pennsylvania  |
| 20. Platinum Metals Review                          | 58. Patents  |
| 21. Comptes Rendus                                  | 59. Battelle-Columbus New Book Lists   |
| 22. Advanced Energy Conversion                      | 60. Special Bibliographies   |
| 23. Chemical Society of Japan, Bulletin             | 61. Manufacturer's Literature  |
| 24. Science   | 62. References cited in reports  |
| 25. Nature  | 63. U. S. Government Monthly Catalog   |
| 26. Sciences  | 64. File users, friends and known experts<br>from word-of-mouth suggestions.   |
| 27. Bioscience                                      |  |
| 28. Journal of Spacecraft and Rockets               |  |
| 29. Federal Procurement Daily                       |  |
| 30. Commerce Business Daily                         |  |
| 31. Faraday Society, Transactions                   |  |
| 32. Naval Engineer's Journal                        |  |
| 33. Chemistry in Canada                             |  |
| 34. Oceanology                                      |  |
| 35. Environmental Science and<br>Technology         |  |
| 36. Army Research and Development<br>Magazine       |  |
| 37. Aerospace Medicine                              |  |
| 38. Elektrokhimiya                                  |  |
-

Of more direct value to the project were expressions of the usefulness of the Index by the technical men doing battery research. Comments were solicited from technical members of the project on two questions. Engineer reactions are summarized below:

Question 1 was based on a request from the project monitor, dated February 20, 1969, Paragraph 2, which reads as follows:

"2. It is suggested that consideration be given to obtaining expressions from the project members on the value of the Battery Information Index to their work, particularly regarding the special reports."

All authors of special reports have used the Battery Information Index and have said they found it useful. Two technical men found that the system did not contain the information they were searching for. It was stated, however, that even this negative result was of help to their immediate tasks because a lack of information could indicate that (1) an approach to a problem being considered was possibly unique or (2) the interest area was judged to be too specific by another technical man to be included in the system and the information would have to be found elsewhere.

Aside from writing reports, engineers reported that they have found the Battery Information Index useful in (1) checking out ideas, (2) maintaining awareness of the present state of the art in sealed batteries, (3) providing assistance in the planning of proposed work, and (4) assisting with various day-to-day work activities. This latter point might include such peripheral uses as checking the spelling of an author's name or determining his official title, the present name of a facility that has just merged with another company, the name of the organization a particular author is presently associated with, or the locations of research laboratories for various organizations, etc.

The Battery Information Index presently is meeting the needs of its users. As of March 1969, the Index contains approximately 1300 documents. As the Index continues operation, the size of its holdings will increase as a matter of course. This growth will impose a need for an accompanying set of plans for system alterations to maintain the effectiveness of the Battery Information Index. Part two of this report considers some alternate methods for handling battery information in the future.

## PART TWO

### POSSIBLE MODIFICATIONS OF THE BATTERY INFORMATION INDEX

#### Introduction

Future efforts must be directed toward effectively serving the information needs of a larger group of battery technologists dealing with larger amounts of battery information.

#### Expanded Information Operation Concepts

One possibility for an improved system is to expand the Battery Information Index into a Battery Information Analysis Center. A memorandum discussing definitions of an Information Analysis Center is attached as Appendix III. Also, Exhibit 8 of Appendix I shows the salient features of an Information Analysis Center. Users are seen to have a technical intermediary between themselves and the large amount of information. With either the Information Analysis Center (IAC) of Exhibit 8 or the Library of Exhibit 9 in Appendix I, the information system is subject oriented and theoretically independent of personalities. That is, a library or an IAC emphasizes what is wanted rather than who wants it.

Another concept for handling battery information might involve development of less time-consuming methods for preparing indexes than using the present Battery Information Index format described in the previous section. This indexing activity may become more critical as the collection of information grows. A report by Mr. W. D. Penniman of the Information Operations Group at Battelle's Columbus Laboratories discusses procedures for automation of the Battery Information Index. Short-range procedures capable of being implemented within a few months are discussed together with long-range plans. This discussion is attached as Appendix IV.

A different approach to an improved information system is to emphasize personalities and personal wishes. Subject matter is then of secondary importance. For such a highly personalized system, procedures are needed for handling specific informational requirements for users having interest in different aspects of battery technology. Special techniques will be required to provide all users with an easy access to the total collection of documents and, at the same time, to emphasize information of greatest interest for each user.

A recent survey<sup>(18)</sup> on the attitudes of the IEEE membership regarding information indicated that the most important service provided to members was a personalized alerting service.

One technique for decentralization involves issuing complete indexes to all users, with special accessions lists of selected references relating to specific battery interests. As mentioned in Part One, this procedure is being tested at the present time with two groups and appears to be working fairly well. The paragraphs to follow will recommend continuation of a total system with selected parts to individuals.

Another technique for decentralization relates to a total collection concept which might involve the use of microfiche-type cards.

The use of microfiche rather than microfilm appears to be more adoptable to a personalized information system for several reasons:

- Microfiche has a versatility not available with film reels. It can be removed from the system individually. One microfiche may be easily compared with another, and it may be rearranged for any temporary usage.
- Microfiche is made up of self-contained units. There is no need to wind through a reel of film 100 feet in length to find one frame. There is also no necessity of tying up access to a 100 feet of film (an equivalent of 3,000 frames or abstracts) to look at 60 or less frames.
- Readers and printers for microfiche are easily operated. There is no reel to thread, as with microfilm. No complex procedures are involved in order to get the microfiche reader ready for usage.
- Microfiche readers are inexpensive — reported to be under \$100. Portable readers are available so that the microfiche may be used in the laboratory, office, and home.
- Microfiche can be mailed in standard letter-size envelopes to participants in the system anywhere in the world.

With this microfiche technique, all of the abstracts in the Battery Information Index first would be placed on microfilm. This microfilm would be cut and inserted into acetate film holders to effect a microfiche. Microfiche negatives may also be made directly by using special equipment such as a step-and-repeat camera. This was the original method of producing a microfiche as developed in 1935 by Professor van Sterson of Delft Technological University, The Netherlands.<sup>(19)</sup> The images are photographed, row after row, directly onto a flat piece of film of exactly microfiche size.

For a personalized system, one microfiche could hold abstracts for at least 20 and up to 60 abstracts. These abstracts could all be on one specific phase of battery technology selected by each individual. Then each user could retrieve small batches of information he considers pertinent to his present interests. A duplicate set of microfiche could be supplied to other persons having similar interests. At this same time, a different combination of abstracts could be placed in the microfiche for persons interested in different aspects of battery technology. Any person or facility interested in a total battery information system could receive all of the microfiche.

Additional benefits of personal information systems have been outlined in the recent literature. A mechanized private file and library for individual use has been proposed by Vannevar Bush.<sup>(20)</sup> This personal machine has been named a "Memex". It is a device in which an individual stores all his books, records, and communications and which is mechanized so that it may be consulted with speed and flexibility. Data selection is to be performed by association trails rather than by indexing. Bush suggests that the creation of an actual Memex is now an attainable dream. Although he feels that it can be done, due to expected initial cost, he expresses doubts as to whether it will be done.

A certain amount of similarity exists between Bush's proposed personal information machine and the above microfiche proposed for a personalized information system. Agreement is found in the following quote:(20)

"It (machine or system) is worth striving for. Adequately equipped with machines (or systems) which leave him free to use his primary attribute as a human being - the ability to think creatively and wisely, unencumbered by unworthy tasks - man can face an increasingly complex existence with hope, even with confidence."

#### Commercial Information Systems

Other techniques also have potential applications for personalized battery information systems. Some techniques demonstrated in conjunction with the 31st Annual Meeting of the American Society for Information Science which was held at the Sheraton-Columbus Motor Hotel on October 21, 1968, are briefly described below:

(1) The (Data) Central is a generalized, computer-controlled information storage and retrieval system offered by the Data Corporation, 7500 Old Xenia Pike, Dayton, Ohio. The user initiates communication with the (Data) Central system by means of a special dial telephone called a Data Phone. After communication is established, the user queries the system and receives answers on all contemporary console devices, which are linked from any distance with the computer through the telephone line. There are two basic computer software subsystems comprising the total (Data) Central System: (1) the update subsystem and (2) the search subsystem. The function of the (Data) Central update system is to construct and maintain the central data bank. The querying of the data base requires a remote terminal and a data communications link to the computer center. The connection to the (Data) Central System is made by dialing the number of the data telephone set of the computer. The computer responds with a question to the user concerning his identification, etc. Messages are relayed between the user and the computer in a conversational mode on the keyboard of the remote terminal.

A decentralized battery information system might use this (Data) Central system in the following way: A complete data bank might be centrally located with technical personnel, such as those at Battelle's Columbus Laboratories. Communication stations equipped with a special telephone and a console receiver linked to the computer through a telephone line might be located both at Wright-Patterson Air Force Base and at Battelle-Columbus or at other laboratories that become part of the system. Users would be equipped with copies of the "(Data) Central User's Guide" and a basic knowledge of the type of information in the particular data base.

(2) The CC-30 Communications Station was demonstrated by Computer Communications, Inc., 701 West Manchester Boulevard, Inglewood, California 90301. This CC-30 Communications Station consists of a TV display controller, an alphanumeric keyboard, a telephone coupler, and any standard TV receiver. The TV display controller displays alphanumeric or graphic data on a standard television receiver, accepts information from a keyboard or other input device, controls all input/output devices at the station, and communicates with any computer. The cost of the basic equipment was quoted to be about \$7545 or approximately \$215 per month by lease; it includes a CC-300 TV receiver, a CC-301 TV display controller (containing a character/graph generator

and a buffer memory and control), and a CC-303 alphanumeric keyboard. A network of 64 slave TV display stations could be maintained.

This network could be used for a decentralized battery information system in ways similar to the (Data) Central System. That is, a central computer such as the one at Battelle's Columbus Laboratories could be used as the central station. It would have slave stations located at Wright-Patterson Air Force Base, in the various laboratories at BCL, and elsewhere. The amount of special equipment required may be somewhat reduced, as a standard TV may be used as a receiver. The equipment is said to be portable, which would be an asset in crowded laboratories. Equipment may be leased rather than purchased outright, thereby providing an opportunity to experiment with the system on a small scale.

(3) The 3M Company demonstrated a less sophisticated system that may prove practical for a decentralized battery information system. Abstract cards would be photographed on microfilm at a cost of approximately 2 cents per page. Microfilm cartridges would then be read and/or printed out on a Recordak reader-printer. One attractive feature about this system is that many laboratories probably already have the reader-printer in their libraries, as it is well-known equipment. Should this equipment not be available, it was said a unit may be purchased for approximately \$1750.

Abstracts of battery documents might be placed on microfilm on a monthly basis. Small sections of microfilm being distributed would contain the Monthly Accessions List. A disadvantage to the use of microfilm might be that the Battery Information Index currently contains under 1500 documents. Abstracts for all of these documents would require considerably less than one-half of a 100-foot reel of microfilm. Updating the film would require numerous splices or frequent replacement of partially used reels.

(4) The Chemical Abstracts Service is the world's largest chemical and chemical engineering information service in the English language. This facility is a self-supporting division of the American Chemical Society. "Chemical Abstracts" is published in five major sections: (1) "Physical and Analytical Chemistry", (2) "Macromolecular", (3) "Biochemistry", (4) "Applied Chemistry and Chemical Engineering", and (5) "Organic Chemistry". Other publications include: "Chemical Titles"; "Chemical-Biological Activities"; "The Naming and Indexing of Chemical Compounds From Chemical Abstracts"; "Chemical Abstracts List of Periodicals"; "The Ring Index"; and volume and collective indexes for authors, subjects, patent numbers, and formulas. Services include: chemical titles tapes and searches, compound registry handbooks, chemical abstracts on microfilm, Russian photocopy service, and nomenclature services. These services and publications are derived from one fund of information.

Information services may also be provided through the CA Condensates data base. Condensed abstracts consisting of title, author, reference, CA abstract number, and index terms are issued weekly on magnetic computer tapes supplied by subscribers. The annual subscription price is \$4,000. Custom computer searches on CA Condensates are also available for \$4,000 per year. A search is run on CAS computers on each of the tapes issued during the year, and the search results are sent to the subscriber. The subscriber pays the cost of the computer search operations in addition to the subscription fee. This particular technique does not appear to be compatible with the anticipated cost and convenience requirements of a personalized information system.

The data-base concept, however, is particularly interesting as a possible technique for an improved battery information system. Thus, the microfilmed version of

Chemical Abstracts or other abstracting services might be used for a data base on electrochemistry (or batteries). From this common pool of information, tabletop indexes could be prepared for each group of file users and their specific areas of interest.

(5) The Eastman Kodak Company demonstrated a "Microcode System" which includes an electronic keyboard console in combination with a Recordak-type reader-printer. A similar unit is presently in operation at Wright-Patterson Air Force Base. This system allows information retrieval from photographic files. With the usage of film it is possible to obtain immediately an identification number, an abstract with bibliographic data, or an entire document. Term location can be random and there is no limit on the number of terms for a document. The document identification is sequential, followed by its terms. Only a few hundred items (assuming one frame for abstract, etc., and not over 40 terms per document average) can be placed in a film magazine. There is no limit, however, to the number of magazines that can be used. Up to 15 terms, one per keyboard, may be combined in a question on available equipment, provided the vocabulary does not exceed 2,000 terms. The particular system in service at WPAFB has 14 paired keyboards and has a limit of seven terms per question. The unit is operating with a 10,000-word thesaurus. (21)

It would appear that the required hardware (multiple-paired electronic keyboards in combination with a microfilm reader-printer) of this system would limit its portability and thus limit its application to a personalized information system.

(6) The Termatrix System was offered by the Jonkers Corporation. This information technique is based on an optical coincidence design. A separate file card is maintained for each subject term. The cards may be punched or drilled to effect the storage of document numbers associated with a given subject term. Each card has a capacity of recording 10,000 documents. The system does not appear to be promising for the needs of a battery information system, as it seems to be orientated toward very large systems containing somewhere in the neighborhood of 50,000 documents or more. A standardized code might be needed with this system.

Subsequent to the above mentioned meeting of the American Society for Information Science, Cryptanalytic Computer Sciences, Inc., announced a new retrieval system composed of five basic components or subsystems: (A) The Query or File Interrogation Subsystem, (B) The Index Subsystem, (C) The Descriptor or Nomenclature Subsystem, (D) The File Organization Subsystem, and (E) The Output or Report Organization Subsystem. The essence of their unique contribution is derived by combining the technology of cracking codes with the technology of using computers for the filing and retrieving of large amounts of information. (22)

#### CONCLUSIONS AND RECOMMENDATIONS

As a result of the experiences upon which this report is based, the present system of the Battery Information Index should be drastically modified. These modifications are needed:

- (1) To supply larger quantities of information to an engineer or scientist at his working level in such a way as to help him and to decrease the amount of nontechnical work.

- (2) To enlarge the role of information specialists as a link between available scientific knowledge and an engineer's problem.
- (3) To provide a flexible system such that surveillance of the total literature for an individual is more easily changed as his technical interests change.
- (4) To increase the ease with which information can be stored and retrieved at an individual's desk or work station or a station suitable for a small number of individuals.
- (5) To enable wide audience (Government and industry) participation with battery information.

The Battery Information Index system described in this report to a large extent already accomplishes the above first four basic needs for a decentralized personal system. However, the recommendations for modification were said to be drastic for two reasons. First of all, a recommendation to expand a flexible system for catering to an individual's changing needs is contrary to a general trend toward computerized systems that are independent of individuals. Simpson(23), for example, says,

"While techniques for handling information will be gradually improved in the years to come, the basic methods have been established, and at this point no revolutionary methods appear to be emerging. The really important changes for the future appear to lie in management functions and standardization of formats."

The recommendations to follow are aimed (1) at minimizing costs, (2) at decreasing Government responsibility, and (3) at utilizing existing systems. All three of these aims are drastic because they are opposite to the more usual requests for (1) more money, (2) Government support, or (3) proliferation of systems.

The basic concept being recommended is to individualize present services to a wider audience of users. This recommendation is based on a belief that the proposed system represents a practical middle-of-the-road approach to handling large amounts of battery information for a wide variety of individuals. Continued operation of the Battery Information Index within its present format will probably result in a large depository of battery information that is time consuming to use. It has been observed that, as the size of an information system increases, efforts are gradually and increasingly directed toward system maintenance and development and away from control and use by individuals. This result is in direct opposition with the conclusions drawn from the work session described in Appendix I, pp A 3, A-11, and A-12, namely, that information must be used if its collection is to be justified.

At another extreme from personalized systems is the computer approach to handling battery information. While the computer undoubtedly has many advantages, its usage appears to necessitate increased initial funding and an increased number of professional and nonprofessional people for the reasons explained in Part One of this report.

The personalized system shown in Figure 5 is recommended for the present and future users of the Battery Information Index. The components of this system, how it is operated, and its benefits are described in the following sections:

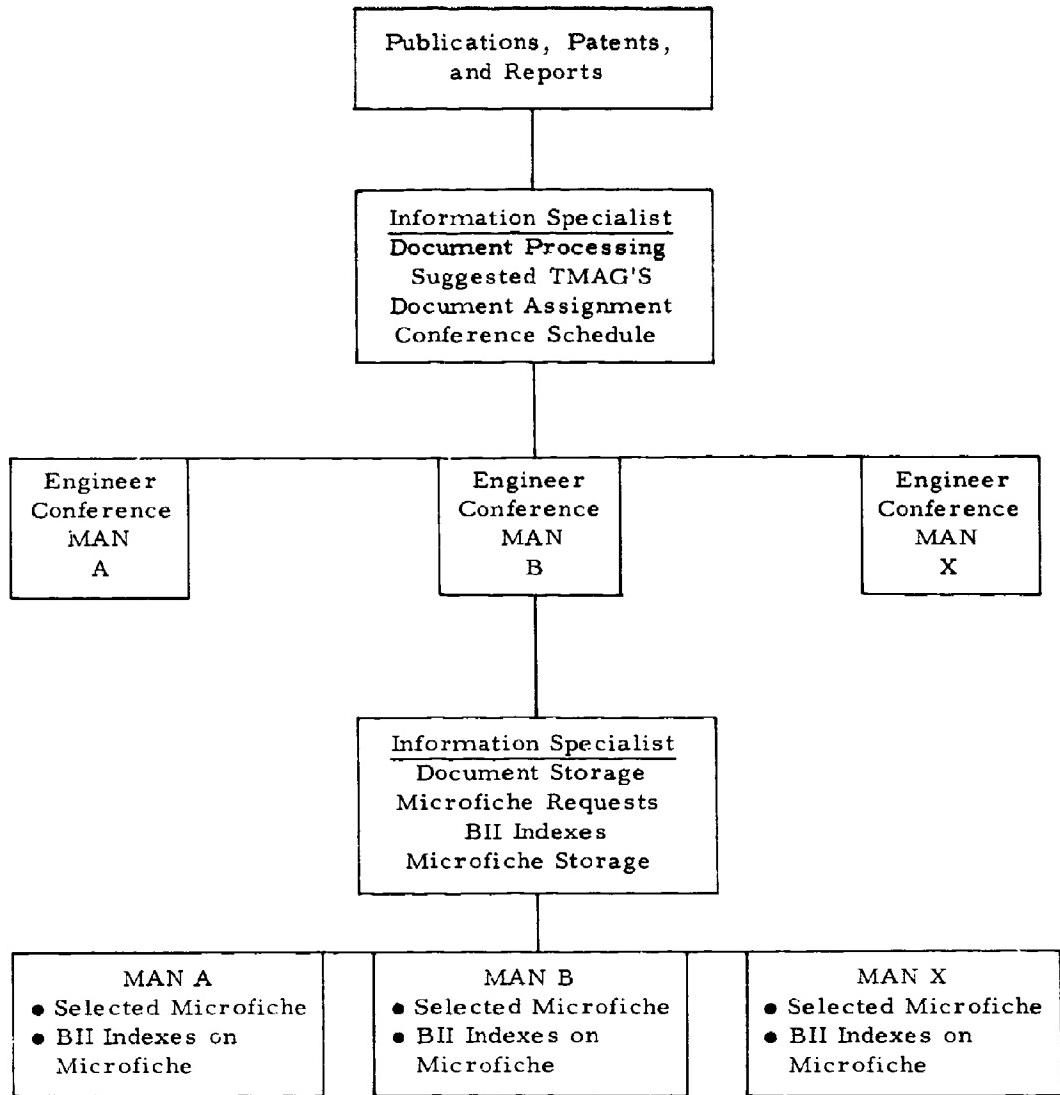


FIGURE 5. INTERACTIONS OF COMPONENTS OF PROPOSED SYSTEM

The operating procedures for the proposed system shown in Figure 5 are given below:

#### 1. Document Input

Sources of information would come from continual scanning of presently circulated journals by information specialists, as indicated in Table II of this report. It may be advisable to step up document-ordering procedures to provide faster acquisition of selected reports. Documents would be acquired through primary distribution lists whenever possible. Copies of U. S. Patents would be obtained on a continuous schedule.

#### 2. Document Processing

The information specialist will perform several bookkeeping chores including document logging, document assignments, distribution, and the scheduling and holding of engineer conferences. Upon completion of engineer conferences, engineer-prepared abstracts plus indexing terms would be incorporated into the existing system. Requests for microfiche would be processed. The documents would then be stored in the Battery Information Index.

#### 3. Microfiche

On a regular schedule, perhaps on completion of engineer conferences, the information specialist will obtain microfiche for all engineers according to their interest areas. Microfiche will be prepared and distributed by BMI or outside service groups. The Battery Information Index will maintain a complete set of microfiche which will permit duplication of any engineer's collection of battery information.

#### 4. Required Equipment

Sponsors would provide each user of the Battery Information Index with an individual microfiche reader. A microfiche enlarger and printer would be made available for several users. Each user would have a separate file in which to store his microfiche for use at his desk or work station.

#### 5. User Interest Changes

As the interests of a user changes, new searches would start through sources listed in Table II. New users can be added to the system at any time. Users may drop out of the system at any time.

This proposed plan for the Battery Information Index offers a practical means for realizing a system for making large quantities of battery information available to a large audience. This plan also ensures that the system will provide an optimum match between the user and his needs by virtue of the user's active participation in the important activities of abstracting and indexing. This plan also permits the system to grow and/or change as the user base, data base, and interests grow and/or change.

## APPENDIX I

### TRANSCRIPTION OF TAPE FROM JOINT WORK SESSION ON LITERATURE PERTAINING TO "FAILURE MECHANISMS ON SEALED BATTERIES"

Tuesday, February 21, 1967  
Lobby Conference Room H, Battelle-Columbus

#### Attendees:

Dr. E. W. Brooman, Research Electrochemist, Electrochemistry, Battelle-Columbus  
Mr. P. W. Cover, Physicist, Electrochemistry, Battelle-APL  
Mr. R. L. Darby, Chief, Information Operations Division, Battelle-Columbus  
Dr. C. L. Faust, Chief, Electrochemical Engineering Division, Battelle-Columbus  
Dr. R. W. Hardy, Research Electrochemist, Battelle-Columbus  
Mrs. D. M. Johnson, Information Specialist, Electrochemistry, Battelle-Columbus  
Miss N. H. Kronemer, Information Processing, Battelle-Columbus  
Mr. O. L. Linebrink, Associate Fellow, Instrumentation, Battelle-Columbus  
Mr. R. A. Marsh, Program Engineer, Battery Task, Aero Propulsion Laboratory  
Dr. J. McCallum, Project Director (-3701), Battelle-Columbus  
Mr. G. H. Miller, Project Monitor (-3701), Aero Propulsion Laboratory  
Mr. E. A. Roeger, Jr., Physicist, Electrochemistry, Battelle-APL  
Mr. D. E. Semones, Research Electrochemist, Battelle-Columbus

## APPENDIX I

TRANSCRIPTION OF TAPE FROM JOINT WORK SESSION  
ON LITERATURE PERTAINING TO  
"FAILURE MECHANISMS IN SEALED BATTERIES"

Tuesday, February 21, 1967

McCallum We're going to call this a work session and, because nothing has been rehearsed, we'll have to play it a little bit by ear. I think we might just point out first for everybody, that from Wright-Patterson Air Force Base we have Miller and Marsh. (Introduction of people from Battelle.) You might notice also that we have a tape recorder running here as part of our meeting this morning.

The main objective of our meeting is to lead up to a report on voids and inadequacies in battery literature. This objective comes about from the first paragraph of our Statement of Work, paragraph 2.1, which says that we are to conduct a literature survey to define areas of inadequate nickel-cadmium and silver-zinc battery technology and to recommend a technical plan for supplemental research to fill the voids and to correct the inadequacies.

Now one of the first problems we have with a statement like that is what does it mean? How are we going to agree on what are the voids and what is inadequate? So some agreement on meaning is one of our main purposes and it's my thought that we can face this problem squarely. I have a few notes. Those who are participating have a few notes. We're going to have some questionnaires. We're going to use you like guinea pigs in some instances. Nancy is going to take a few notes. So between what is recorded, what is written, and the notes that might be taken, I believe we should have the meat here from which we can extract the report about voids and inadequacies and what we intend to do about them. This plan is a little different from the battery workshop that Hardy and I went to in Washington, D.C., recently where the meeting was transcribed verbatim. The difference being that we will start with a verbatim transcript which is just the building material with which to start constructing something useful. We may rearrange it and add to it and everyone here will have a chance to see what they said, to change their words and to say, perhaps, "that isn't what I meant". We'll have a chance to put information down and rework it and use it like it should be used. So, unless anybody has any strong feelings about being recorded, I'll assume no one is objecting.

On the table, by the wall over there, we have several hundred battery documents that have accumulated without too much effort. We've been making a little effort recently to collect pertinent documents. But the big question is, of course, what are we going to do about them? And as I delve into this problem of handling battery information, I quickly realize what an amateur I am and what a complicated situation it is. There's a letter here from a recent issue of the C and E News about the "Proliferating Science Data" in which this man, a James Danehy from Notre Dame\*, recommends that a fact-finding survey should be carried out to determine the range

\*Danehy, James P., Letter to the Editor, Chem. and Eng. News, Dec. 5, 1966, p 7.

and extent of the actual current practices of American research chemists with respect to their dealing with the literature. The article goes on to say, "If there is already any appreciable body of information on this subject, I'm unaware of it". So he's saying, in effect, let's get the facts and find out just how people do deal with literature.

I've asked several people around Battelle, including Ralph Darby, "Is it true that there's been no survey of how engineers deal with literature?"

The answer comes back, as I understand it, "Well, yes and no. There's a vast body of information on this kind of thing but-."

Another interesting quote here comes from John Murdock, who manages much of the information research around Battelle. He points out from observations in one of the information centers that each day over a period of nine years, which adds up to more than 2300 days, there were more than 10,000 searches for bits of information and they observed that the same retrieval sequence never had been duplicated.\*

I questioned that observation and wondered instead of the search never being duplicated whether everybody doesn't do it the same way. This brings us into another gray area that I think we ought to face up to. Namely, is there one way to find information or must there be as many ways as searchers?

Well, I thought that we might start today with a review of where we are on this particular project with battery documents, get some opinions and comments, some remarks from each of you about what we're doing, what we'd like to do, and how we're going to proceed. Then, before we get your minds swayed one way or another, we'd like to do some work with a few documents. Some are here in quadruplicate or sextuplicate so we can have some interesting experiments going today. Ralph Darby is going to speak to us about information operations and then, Ralph, I thought that we might have a work session with some of these documents. After some discussion about the problem we're up against, and what you think we ought to do, maybe we can spend an hour with these. In the afternoon, we'll work some more with the same documents in some other ways.

In some ways this meeting is one of the easiest you'll ever attend. We haven't asked any of you to prepare anything, just come with an open mind and we'll see what happens. Anybody have any questions about why we're here? Dottie, do you want to start talking about what we're doing?

Johnson I prefer to discuss our present status on battery information procedures from the standpoint of following a particular document through our system. At the same time, I'll ask questions and hopefully provide some answers. The first step would be the source, or where do we get the documents? We have over 500 now. We started with a backlog of approximately 200 documents. Machine searches were requested last September from DDC and NASA. I have those searches here. Several sets were ordered from both DDC and NASA: one set on nickel-cadmium and silver-zinc batteries, another set on battery testing techniques, and a third set on thermal aspects of batteries. The first set from DDC on nickel-cadmium and silver-zinc batteries resulted in more than 650 abstracts. This separate pile represents over 400 that have been rejected. Approximately 100 of the abstracts were entered into the system. Approximately 150 are yet to be considered.

\*Murdock, J. W., "Application of Battelle Technique to the Operation of Information Centers", J. Chem. Documentation, 2, 127 (1962).

In this type of search, documents will be turned up dealing with anything that has to do with silver, anything with cadmium, anything with zinc, which means that we turned up fuel cells using nickel electrodes as an extreme example. Some of the other categories include silver-cadmium, of course, primary batteries, zinc electrodes, all types of hardware, ammonia cells, and so forth. The result is a time-consuming operation with battery references. It has been fruitful for those 100 but it took a long time to dig those out of the 500 references reviewed.

Another 200 of the documents came from our own continuing searches and include Chemical Abstracts and journals that we normally see such as Electrochemical Technology, Journal of the Electrochemical Society, meetings, books, patents, and so forth.

The next point I would like to discuss is what we do with them. A document comes into our system; checked for duplication; logged in; an abstract or extract is put on a 5 x 8 file card; document descriptors are selected and added to our various indexes which are distributed to personnel on the project at the end of each month. At that time the document is sent to one of our engineers who has indicated an interest or has requested the document to be ordered in the first place.

The third step is disposition, or what happens to the document. It's sent to an engineer who uses it for background in a report, or he could use the ideas for a new experiment. He may decide, "This document does not have what I wanted", and it can be rejected at this point. On the other hand, he may use the document for other reasons not known to us and then return it. Our job now is to store it until the time that the document is to be retrieved by someone else or the original man has recalled it. The document has been processed into the system, indexed, circulated, and announced to project personnel.

We've gone through an interesting exercise here. The most important thing is the fourth step - the end result: "What good has it done?" "Has anybody received any benefit from this particular document?" These questions, of course, imply that a document must be used and use is the vital point of any information center.

In order for a document to be used, it must first be found in our particular system. So, just as a brief review, let's go through some of the motions of how a particular document can be found. At your stations you have an accession list; you have an author index, and you have a subject index. Suppose that you were interested in documents pertaining to "thermal analysis". You could go to the subject index under "thermal analysis"; it's broken down several ways. Perhaps you are interested in "stress reduction". Below that particular entry, there is a number 333. Now you can do one of two things: (1) you can turn to your accession list, under B-333, or (2) you can check the abstract card number B-333 for additional information. All documents can be loaned for a time. Within the various indexes, documents are categorized several ways. Thus, if you know the contract number, pertaining to work on stress reduction, you can find it in the contract index. This built-in versatility feature can be a convenient retrieval tool. Unfortunately, not all our requests are completely identified. For example, our friends from WPAFB were gracious enough to send up some duplicate reports for us to use today. Yesterday, they told us which ones they would be and I wanted to check our index to make sure that we had them, to check the abstract and to determine how the reports were entered into our system. The information on one of the reports was extremely limited - and this is for fun - ; this piece of scratch paper was given to me by Dr. McCallum, and this could be a normal request: "Yardney report on manufacturing" was all it said.

Now, I don't have an author; I couldn't use that index. I didn't have a contract number or a title, so the only thing we had was "Yardney". All right, let's go to the facility index. So we have a little retrieval exercise. We come to Yardney and we have a large list of numbers. Now large lists of numbers happens to be one of the problems we would like to have your help on a little later today. It's there. We found it, but we had to go through quite a number of abstracts or abstract numbers to locate this particular report referred to merely as "the Yardney Report on Manufacturing". Poor identification is one of the problems we have right now and we need your help.

To see how our particular system is doing at the present time, we've been running some use rates. We've been keeping track of these since last July. "J" indicates July, "A" August, etc.

	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	<u>J</u>
E/M	205	65	45	51	52	41	30
U/M	43	10	66	25	76	28	14
AE	205	270	315	366	418	459	489
A/USE	43	53	119	144	220	248	262

—End Result

E/M represents the documents that we entered into the system per month. The July numbers, of course, are our starting backlog. The other numbers show how entry rates have been ranging by the month.

U/M is the number of documents that was used or loaned per month. You can see that loans vary widely from month to month.

AE indicates accumulated entries, so as of January 31, we have 489 documents in the system.

A/USE is the accumulated use (Circles 489 and 262 under Jan). Those of course are the vital points, somewhere in the neighborhood of 53%.

Last Thursday at WPAFB I was telling about "our man with a problem". I think most of you have seen this picture; just to refresh your memory, see Exhibit 1. In order to serve his particular needs, we should know a lot about him: what technical field he is in, how he prefers to handle his particular information problems, and how quickly he wants his answers. We would like to carry this a step further today, finding out a little bit more about you folks so that we can handle your information problems in the most effective way.

We have a questionnaire that will be given to each of you to complete. There is just one sheet that we would like to have your name on. The other two sheets are optional; you can sign them if you like. After we get the results of these sheets, we can continue a little later with additional questions and answers.

McCallum Would you comment on the searches received from NASA versus DOD; were they just duplicates or some duplication; what is the difference between them?

Johnson We have gone through this one only (DDC on nickel-cadmium and silver-zinc batteries), page by page. Some of the other fellows have gone through the other

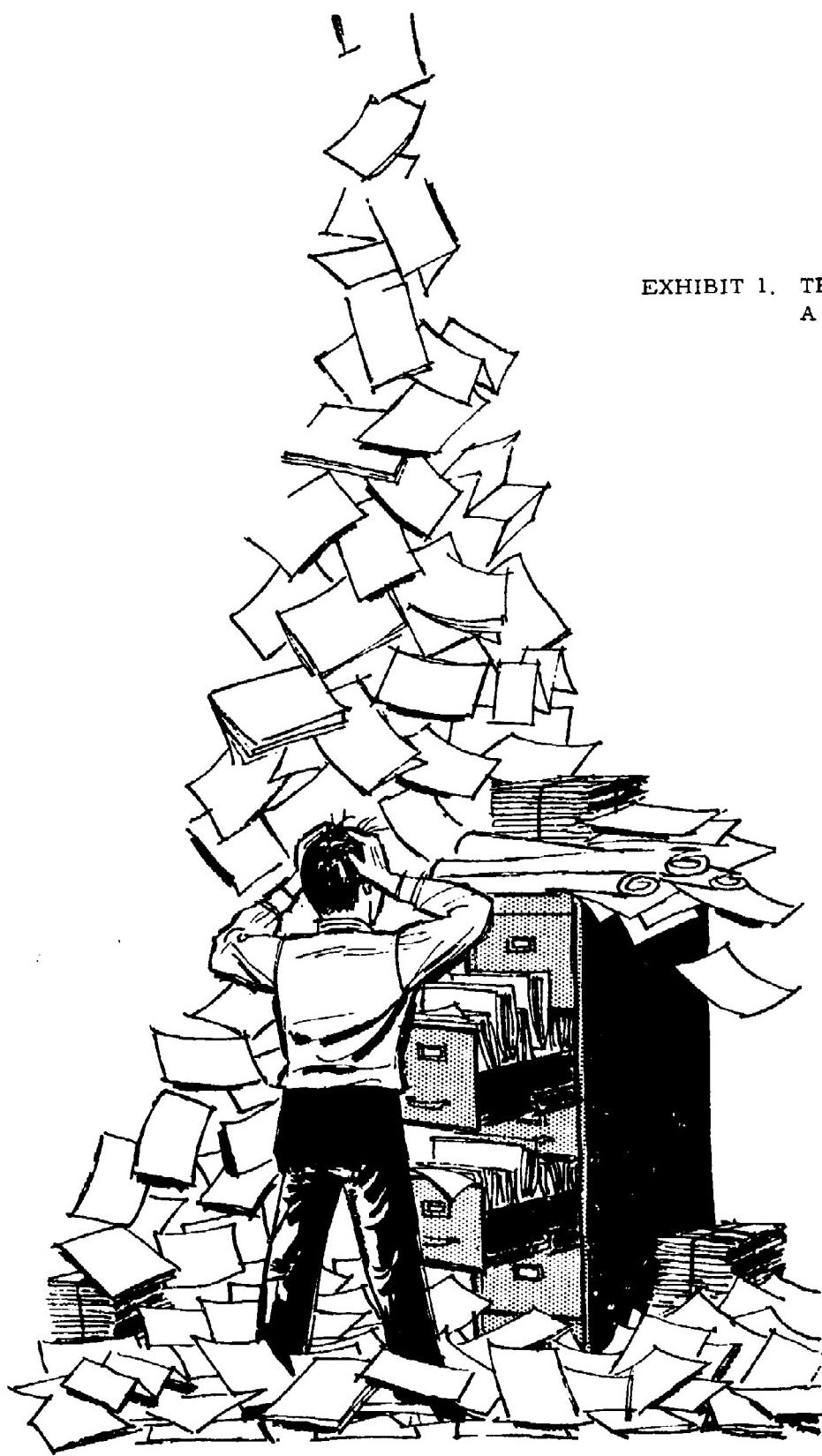


EXHIBIT 1. THE MAN WITH  
A PROBLEM\*

January 7, 1963,  
Chemical Engineering.

searches and they have reported a considerable amount of duplication. So again, all the searches contain noise and useless information to varying degrees.

(Work on questionnaires. See Exhibit 2.)

**EXHIBIT 2. A LISTING OF ITEMS ON A "QUESTIONNAIRE ON  
BATTERY LITERATURE, FEBRUARY 21, 1967"**

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- Item 1. Describe your methods for keeping aware of developments within your own field of interest.
  - Item 2. What is meant by "areas of voids and inadequacies in nickel-cadmium and silver-zinc battery technology".
  - Item 3. List questions for which you currently need answers - hopefully from the available literature.
  - Item 4. Approximately how many times have you attempted to use the subject index (dated November 1966) in the past three months?
  - Item 5. (1) Were these attempts successful from the standpoint of locating a definite area of interest?
    - (2) - a particular document?
    - (3) - specific technical data?
  - Item 6. Please estimate amount of time spent in scanning the subject index for a particular search.
  - Item 7. Suggest ways to handle a large number of references to a given index entry. As examples, Culton has 53 entries, Failure Analysis has 14 entries, and Preparation of nickel electrodes has 33 entries.
- 

McCaullum I think, if I could just interrupt your thinking about these questionnaires, that I might comment on Item 3 on the second page. My comment has to do with questions. What was in mind with Item 3 was a comment that Miller made at one time. His thought was that we're all starting on a new job and we're reviewing these documents, and it would be most helpful if we had a list of questions that we could check against, as we went through the various documents. Thus, you would know what other people were interested in and consequently, as we reviewed the various subjects, we could keep our eyes open for some of these questions. If we didn't find the answers, presumably we just found a void or an inadequacy. So we ought to have some questions. I think all of you might recall the discussion about questions in one of our monthly letter reports (see Exhibit 3). We had a semantics problem. We had a problem of timeliness. Nevertheless, there is some merit in this suggestion for questions, and I wonder if each of you could comment some more about this business of questions in response to Item 3. Let's have a go at this. You've all thought a little bit about this project; what are some of the questions you'd like to find answers to and how would you word them? Let's have the questions, and we'll see what happens with them today. Do you want to comment any more on that, Jerry?

EXHIBIT 3. EXCHANGE OF VIEWS REGARDING THE USE OF PREPARED QUESTIONS

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From APL to BCL\*, October 13, 1966: "With regard to "Literature Reviews", it is suggested that the documents be reviewed against a prepared list of questions. Since literature reviews are being conducted in many areas (Ni-Cd and Ag-Zn batteries, battery measurements, electrode fabrication, failure analysis, and life and accelerated testing), it is felt that review against a "list of desired information" would prove helpful in identifying the voids and inadequacies in the literature of each review category. Your comments on the value and probable contents of review questionnaires are invited.

From BCL to APL, November 7, 1966: "Several of us at Battelle have discussed a review questionnaire and everyone agrees there is a need for cooperation among those reviewing the various categories. Yet, while recognizing a common need, there are differing opinions about how to proceed with literature reviews.

First of all, there often are semantic problems with prepared questions. As actual examples of problems with words, one engineer has asked, "What measures of degradation are reported for observing the performance of batteries on test?" Another has asked, "What is reported about measurement of areas in porous electrodes?" The first question has brought forth no answers. The second question has brought forth so many answers that one can hardly digest the flood of information.

A second problem with prepared questions is that of timeliness. Questions asked by an engineer today are not those of interest tomorrow. From the other direction of helping an engineer, once questions are formalized they tend to become perpetual questions.

Assuming, however, that all problems of semantics and timeliness were solved, one can review literature from the viewpoint of "What is in it?" or from the viewpoint of "What is missing?", or, as suggested by your paragraph, with questions about "What is published about such and so?" We would like to believe that the first viewpoint, namely, "What is in the documents reviewed?" will necessarily lead to the other answers by means of the indices being prepared on this project. Thus, every battery document used, or perused, by technical persons should be subject-indexed by that person. He should add document numbers, where appropriate, to words already in the subject index. He should add words to the subject index as needed to locate information. He should turn to the subject index every time he has a question. In this manner, everyone should become familiar with what is available, as well as with what is missing, about any subject at any time. For this approach to be successful, we need all the technical assistance possible, including help from those persons at Aero Propulsion Laboratory who are interested in this project.

Thus, the use of a continuously updated subject index is preferred to a list of prepared questions. By using the subject terms selected by technical men, the index itself will grow naturally to reflect the current interests and problems of those working with batteries. Voids in the literature can also be pinpointed in specific areas through the absence of references, as noted when persons seek information. The Index should be continuously revised to reflect current research efforts while older references (over five years old) could be supplied on request. This continuous updating would shorten the current subject index and increase its effectiveness."

From APL to BCL, December 6, 1966: "The necessity of a subject index as a means to document and use the results of a comprehensive literature survey is recognized. It is felt, however, that a list of prepared questions would prove helpful when reviewing specific areas within a broad technology. Your plan to collect all available battery information and use a continuously updated subject index for rapid reviewing of any selected specific area is not questioned. The suggestion of reviewing selected technical documents against a prepared list of questions is offered only to assure that the immediate objective of the literature review of the subject contract is not overlooked; that is, identify the voids and inadequacies in the sealed secondary nickel-cadmium and silver-zinc battery technologies."

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\* APL = Aero Propulsion Laboratory  
BCL = Battelle's Columbus Laboratories.

Miller The only comment I would like to make is why I suggested a list of questions. I was picturing myself as the person responsible for electrode fabrication or some other particular aspect of this program. There are certain tasks to do and you review the literature to get acquainted with what was already done in that particular area. In the case of electrode fabrication, one would list what he wants or what he needs to know in the matter of techniques and apparatus. In this particular example, I think many of the technical reports do not go into sufficient detail regarding techniques and apparatus. The exact questions he has in mind may remain unanswered. So it could be that the reports were almost useless to him. He may need to start out fresh, even though many pages have been devoted to electrode fabrication in general. The exact procedural details are not reported and, therefore, a void in the literature may exist. This was the easiest example for me to visualize. Maybe in silver solubilities, or something of that nature, where you have a variety of temperatures and conditions of tests, the literature may be more scattered than absent. You'd have to search further, interpret results, and possibly could not say in definite terms whether a void or inadequacy existed. It may be difficult to compile a general list of questions covering all aspects of this program; however, useful individual lists of questions could be prepared against each separate aspect of the program.

McCallum Right. But don't you think that this work session would be a fine opportunity to list the questions? I know that each of us has some special interests here and, as Jerry says, keep our questions to the job we have at hand and when we work with some of these documents today, we can have a copy of these questions; these will be one of the tools to work with for defining voids or inadequacies. So, if you want some help on knowing something out of all this pile of 500 or so documents, we might receive a little help today from each other.

On the first question (see Exhibit 2), the reason we asked for your name is that Mrs. Johnson is going to help you as much as she can. Let us know what you do. It doesn't matter about your liking our procedures or disliking them. Let's just start with the facts of how you do handle your literature or how you would prefer to have it handled. We're going to like whatever you put down there. The only things we will dislike are a blank on that question or a statement that you don't keep aware of developments.

(Working on questionnaires) (Coffee break)

McCallum Ralph Darby is going to talk to us now about information operations in general. In all fairness to Ralph, you should all know that I just started discussing this meeting seriously with him last Friday afternoon, and he's a busy man. I told him we had this meeting on Tuesday. So I've pulled an unfair trick on him, but he's been most gracious about it and has agreed to just come down and talk about information because he has lived with this for years. That informality is exactly what I thought we ought to have from someone who knows this animal of the literature, what we're up against, and how he has learned to live with information problems. I think you'll find everything he has to say is pretty interesting. So, Ralph, whatever you care to tell us will be in order, I'm sure.

Darby I'd like to keep this very, very informal. If any of you have any thoughts or comments as we go along, please feel free to bring them up. Since I am directly

concerned with some of the STINFO<sup>\*</sup> activities of the Department of Defense, this experiment today is very interesting to me. This represents the type of problem with which we are primarily concerned.

How do we assist the technical man in the effective use of information, and how does he use it? What is information to him? These are types of questions which we have been concerned with since the early fifties when we first became involved with the large-scale information efforts. It is only in recent years that perhaps we are beginning to understand the truly complex relationship that exists between a technical man and his information. This relationship is very personal. Each man has his own way of handling information. What is information to one man may be of little or no value to another man working on a similar problem. And when you look at this problem from the standpoint of designing a universal information system that will match the informational use pattern of a large number of users, the problem becomes even more complex.

The traditional information mechanism has been and continues to be the library. I have to take my hat off to many of the special librarians who serve the highly specialized technical audiences found at many installations. However, at about the same period of time that the first Sputnik and Vanguard were lofted into orbit, man became attracted to the computer and its capabilities to rapidly perform certain types of manipulations. Man began to develop all sorts of new systems for handling information based upon the computer's capabilities. Probabilistic indexing, citation indexing, and coordinate indexing represent various indexing systems designed for computer manipulation.

The traditional library tool has been the abstract journal, such as "Engineering Index", "Chemical Abstracts", "Physics Abstracts", and "The Readers Guide to Periodical Literature". Most of these abstract journals, with a few notable exceptions, such as "Chemical Abstracts", have failed to provide exhaustive coverage of the literature.<sup>\*\*</sup> There just is not enough money and manpower available to cover the total literature. This means that both the technical community and the information community must find new ways of indexing the literature. It is only natural that the computer should appear attractive.

Now, I would like to return to the question I raised earlier. How does the technologist use the literature? How does he keep aware of new technology?

Marsh I have one statement. Do you feel that the scientific type actually creates this complexity in the information? For example, if you are searching for information pertaining to, for example, the oxygen-consuming electrode, one finds many different terminologies; it may be called third electrode, auxiliary electrode, adhydride, charge-control device, and the choice of key words isn't used in a survey. If you standardized the terminology and could get the scientific type to use it, maybe you would avoid the complexity. But each battery company wants to use their own trade name. How do you search out GL-70 or something like this? Such terms mean nothing. All the terms relate to the same project or same search, but maybe you're interested only in the "oxygen-consuming electrode". How do you submit that into the information center so one obtains all the desired information?

\*STINFO stands for the Scientific and Technical Information activities within the Department of Defense. (See AD 299 545.)  
\*\*The giant, interdisciplinary, Federally-supported services such as USGRDR, NSA, TAB, STAR, and C-STAR of course continue to expand.

Darby There's considerable thought being given to just your question. The "battery area" is not unique in this problem with synonyms and word choices. This occurs throughout all science and technology. It also occurs whenever one attempts to translate the foreign literature wherein each discipline group with the foreign countries has developed its own specialized terminology. There has been considerable thought given to this, I think both by some of the STINFO areas within the DOD sector and also at the COSATI\* level within the civilian sector. Perhaps someday we can standardize language.

At one point, an attempt was made to standardize the titles to journal articles and reports in order to make them more meaningful from the standpoint of permuted title indexing (KWIC or KWOC\*\*). Author abstracts or "abstracting at the source" has been considered as a solution to this costly area of abstracting and perhaps someday we can go to that extent. However, this causes further problems in lack of standardized language.

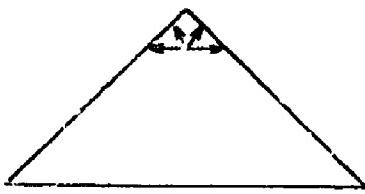
Today, in the information field, they are attempting to solve lack of standardized vocabulary by means of a "thesaurus". Most of you are aware of "Project LEX". This is an attempt by the DOD to develop a standardized vocabulary for all STINFO activities within DOD. However, regardless of these efforts, the technologist, the engineer, and the scientist each remain an individual. As an individual, he is going to utilize the word patterns that best describe the experimental work, or the research which he is conducting. In answer to your question (Marsh's), it happens to be one of the peculiar characteristics of certain men that they like to invent new descriptive phrases and they continue using such descriptive phrases.

Hardy There is, I think, another factor, too. Say, take your GL-70. To an advertising man, you know, he's thinking in terms of catchy phrases and so he may look at them in that sense. The man who puts it in the toothpaste may look on it as a particular chemical compound. In other words, the man who synthesizes it in the laboratory has it in one frame of reference. The user, the man that puts it in the toothpaste himself and is looking for a brightening agent or something, considers it as a functional unit. So that you have definitions depending on where you stand, I think this is one of the reasons you have differences, as well as the arbitrary thing you're speaking of.

Darby Let us carry this type of thinking one step further. The pharmaceutical manufacturers have the problem of developing catchy trade names for their products. They have gone so far as to seek all phonetically acceptable six-letter words. The computer was used to develop all possible six-letter combinations. These permutations were then examined to determine those combinations which were acceptable as trade names.

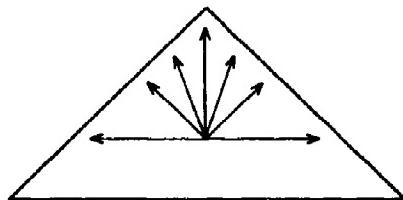
To return to our discussion of the information problem, most scientists will tell you they don't have an information problem. Now, this is generally correct at the top scientist's level. You can picture a discipline in the form of a pyramid. The top scientists apparently have a limited audience with which they correspond. They possibly review the work of their peers before it is published. Therefore, he knows the experts and what they are reporting.

\*Committee on Scientific and Technical Information.  
\*\*Key Word in Context or Key Word out of Context.



Marsh He thinks he knows that; he may not.

Darby I agree; this is subject to question. But to a certain extent he doesn't have the magnitude of the problem faced by those in the technologies, in the engineering areas. These people must communicate with a much larger audience of peers than the top scientists.



Just to illustrate this one step further, if you get down to the bottom of this pyramid, down to the poor design engineer, then you've really got a problem. It used to be that a design engineer sat down at his drafting board with his calculator or slipstick. Next to him was a set of nice handbooks; if he needed to know the strength of an I-beam or an L, he could go to it. He could slip his constants into the proper equation and he could design his bridge. But today, when we're working with, for example, the exotic, high-temperature materials such as refractory metals, refractory alloys, these physical constants may no longer be arranged in handbook form. New materials are being developed and used faster than their physical and mechanical properties can be standardized and put into handbooks. To compound this problem, we have discussed only one discipline. Actually, most work is interdisciplinary in nature. When these technologies overlap, the problem is compounded. I suspect this overlap of technical areas is where the top scientists begin to run into problems.



Now, these men at the working level (the technologists) are not concerned with fancy information systems. The only thing that they are concerned about is that they receive the information or data at the time they need it. If it is received 24 hours later or a week later, it's useless. It's also relatively useless if it comes to their attention a week early because at that time he doesn't know he's going to have the problem. This is one of the real problems in information: how do you get the information to the right person at the right time?

I was talking to a colonel recently who had an interesting problem. He was literally spending thousands of dollars putting out the tech manuals on aircraft maintenance. His problem was: how could he be sure that the corporal out on the flight

line was going to read that latest addendum that changed the specification on how tight a particular nut on the engine mount was to be tightened. There is just no way of being sure that the corporal would read and remember each change in specifications at the time he picked up his wrench.

We have tried to model the technologist as a user of the technical literature. (See Exhibit 4.) The total literature flow is illustrated across the top of the figure. Since this total flow is too large to encompass, the technologist makes use of various switching stations in order to assure the proper flow across his desk. For example, he may subscribe to certain journals or ask the library to circulate certain journals to him. Or the secretary may be instructed to call certain types of documents to the technologist's attention. As the journals or reports cross his desk, the technologist acts as a qualitative filter. Each man does this differently. Some read only the table of contents. Some thumb through the journal. Many men underline important passages. Others bracket information. Regardless of how he does it, he is qualitatively identifying information that contributes to his thinking and knowledge.

Next, he must store this useful information in some manner. Some people have photographic memories, and one of our favorite stories at Battelle concerns Horace Gillett, the first Director of the Institute, who could leaf through a report just about this fast, so they tell me, and remember everything that was in it. Then he'd go down the hall and talk to various staff members about what was in the report. I don't have that ability; very few of us do.

You have to store information in one way or another and herein we get into a lot of fun because many technical people try to have some type of storage device in their office - file cards, edgenotch cards, or files of tear sheets and photocopies.

There's another type of man who, in his office, has a desk behind him piled high with various reports or journal articles. This type of man has one of the best retrieval systems you ever saw. You can ask him for information on some subject. Then he'll say, "Let's see now, that's in this pile, down about halfway" . . . , and he'll pull it out.

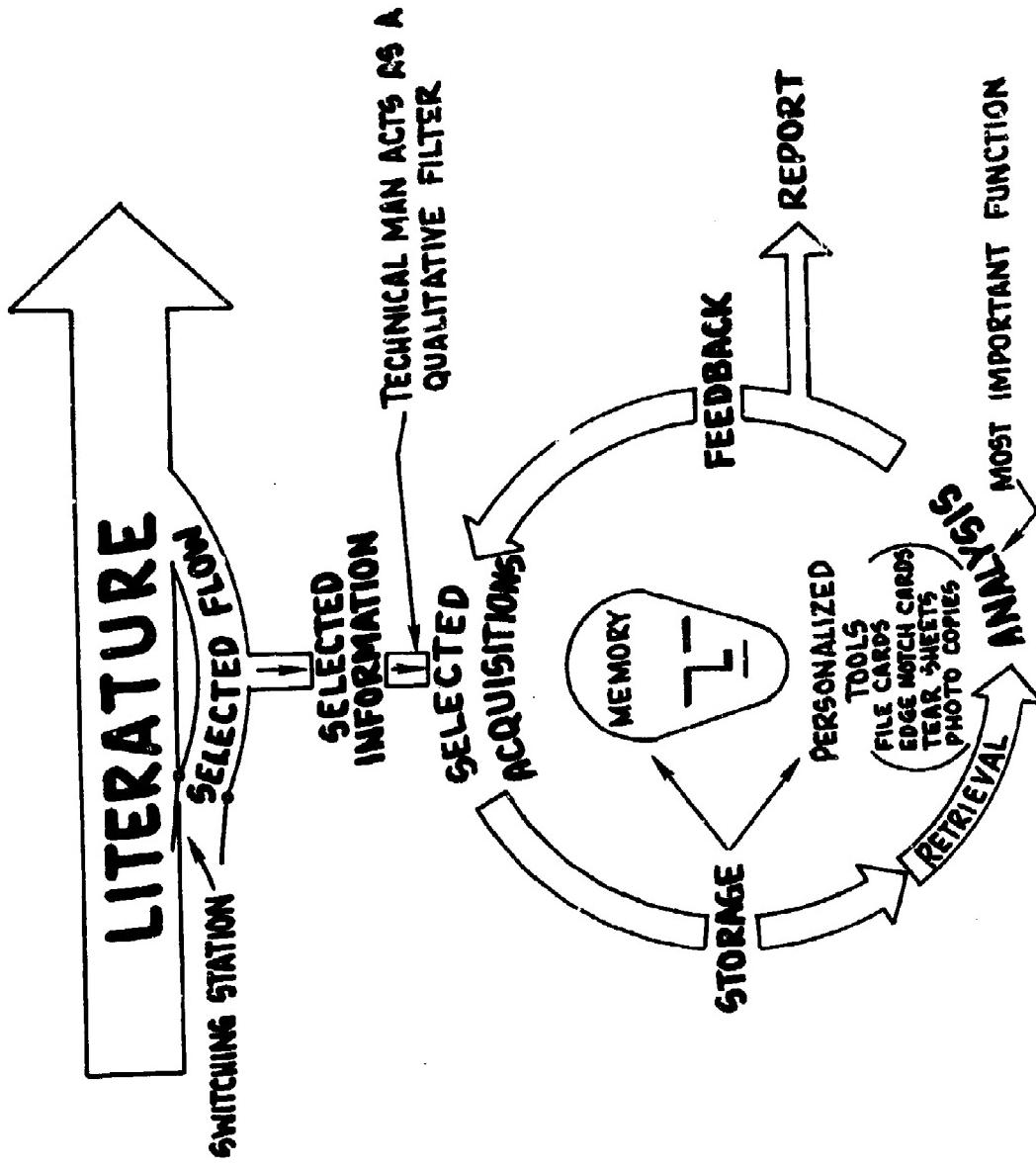
This behind-the-desk retrieval system is good as long as that particular man stays active with it. Right now we have a situation in a company in New York City in which such a man has been promoted to management duties. The technical man who replaced him is saying, "I have a room full of information and I can't retrieve the first bit." It will probably cost 10 or 15 thousand dollars just to gain control of the first man's information.

In other words, many of these personal storage systems soon become so costly in terms of time and effort that they fail.

Next around the circle of our model is retrieval. The telephone rings; the boss calls. "By tomorrow noon I want a report on--." And then the mad scramble starts. Our man immediately will search his memory to try and retrieve the necessary information. Next, he will go to his personal system to retrieve information. He may obtain the information from his associates. Or, he may go to the library.

Next comes the most important function - analysis. In a cyclic fashion he analyzes, he goes back for retrieval, he analyzes some more, goes back for yet more information. To complete this model (see Exhibit 4), he will then make his

## EXHIBIT 4. INFORMATION ACQUISITION



report to management. However, there is another interesting phenomenon that takes place at this time: feedback. Feedback completes the cycle and modifies the qualitative filter of selective acquisition. That filter is never the same one minute to the next. It changes constantly. What constitutes useful information today may no longer be useful tomorrow.

You can try out any information system in this man-model. If the system seems to fit into this man-model, then engineers may accept the system. If the system does not fit into this pattern (Exhibit 4), then users may reject it. Now, I'd like to go back to this point of retrieval.

Linebrink Is it the use pattern he rejects or is it the lack of delivering the goods?

Darby He will reject the system for a number of reasons. If the system does not deliver the goods to him, he will reject it. If he must expend too much effort to utilize that system, he may reject it, depending upon his need. For example, Dottie was asking questions on indexing. She mentioned some of the problems she has had in indexing some of the documents. We could develop an index system to match each man's retrieval pattern. Obviously, this can't be done for all men, so we attempt to strike some average. But the index can be tested by putting it into that context of the Information Acquisition Model (Exhibit 4).

Now, in a problem-solving context, there's an interesting phenomenon happening. We tend to think of literature as being all important. This is a mistake. I believe that literature is one of the least important sources of man's knowledge. We have found that the average technologist acquires his information in many other ways than from the literature. Case Institute of Technology did an operations analysis study\* of the chemist, and they found out that the chemists spend 35% of their time in communication, at lunch, coffee breaks, etc. They are, in fact, acquiring useful information at such times. So when we consider the total information flow as represented by the large arrow at the top of the diagram (Exhibit 4), telephone calls, meetings, letters, memoranda, and other forms of informal communication must be included. Unless this informal communication flow is captured, the information will become outdated.

Marsh Doesn't the flow of published literature help you to define who you should communicate with informally?

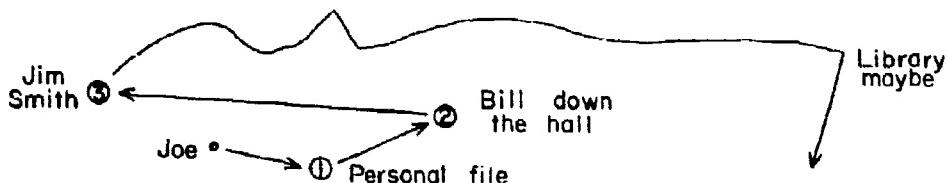
Darby Right. This is one of the most important aspects of the literature flow. But how many people really use the library catalogue to this particular advantage? In other words, who goes to a library catalogue, looks up a subject, identifies men, and then immediately goes to the author file and sees what all that man, as an expert, has written? This can be a very important mechanism when used properly.

But this brings us back to how our man retrieves his information for a given problem. Here's Joe. The telephone rings; the boss says, "I want a report by tomorrow morning." Does Joe go to the library? No, he goes first to his personal

M. W. Martin and R. L. Ackoff, "The Dissemination and Use of Recorded Scientific Information", Management Science, 9, 325 (January 1963).

file to see what is in there. He doesn't have the information; perhaps Bill down the hall has some useful information. Bill riffles through his files and reports. "I don't have anything, but I remember Jim Smith over in the next department was working on something very similar to this last week."

Somewhere along the line Joe may request help from the library. But I find he goes usually to an information system or a library relatively late in his first search effort. Joe's approach may appear to be random in nature at this point.



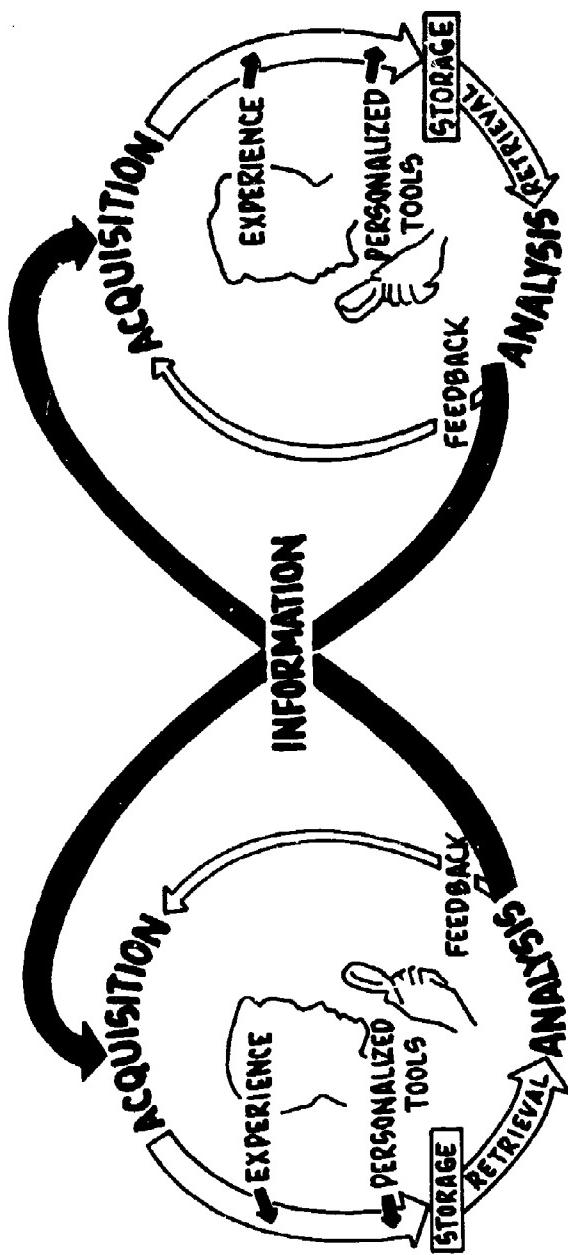
This random procedure is not necessarily wasteful. In taking the random approach, the technologist is seeking to identify the optimum path to arrive at a solution. We can use the man-model (Exhibit 4) to illustrate the case of two-way communication (Exhibit 5). The first man is attempting to deliver a message to the second man. The second man's ability to receive the message may depend upon how early he got to bed last night, whether he had a good cup of coffee in the morning, and what his boss had to say to him this morning when he arrived at work. He may be accepting the information coming to him. On the other hand, he may be concerned about some problem, in which case he may not receive your messages. There may be a mismatch of the two qualitative filters and communication is impossible.

You can picture this in various modes - 1:1 communication; 1 to a mass communication (which is the situation I have this morning wherein I'm communicating to you as a group); man-machine communication or machine-machine communication.

I brought with me an example of one attempt at man-machine communication. We are using the computer to manipulate data, which is, after all, the real purpose for which computers were designed. These data deal with strength of materials, elasticity, strength, and elongation, for a particular type of alloy which has had a particular heat treatment. Instead of just printing out the data, we've gone a step further in this communication exercise and now we're bringing out plots of several compatible sets of data together with the best fit curve. (Shows examples given in Exhibit 6.) This one happens to be for yield strength vs temperature. It is illustrative of an attempt to make the man-machine interface more meaningful to the technical user.

Semones Before you go on, Ralph, I wondered why the random searching might not be a good thing. I think we agree there. My point is that any person seeking the knowledge knows that most of the things he lifts out of the library will come down unevaluated. On the other hand, Jim Smith over here may say, "Professor Washburn in Washington has done a good piece of work in that area and I think he's got the right equations to describe your problems, say, on selecting a battery." Now, Jim Smith's remark includes an evaluation. Here's a clue that if I find that particular material, it will probably be worthwhile. So this random search gives you something to gain, so far as finding useful information is concerned.

## EXHIBIT 5. SCIENTIST TO SCIENTIST COMMUNICATION



A-17

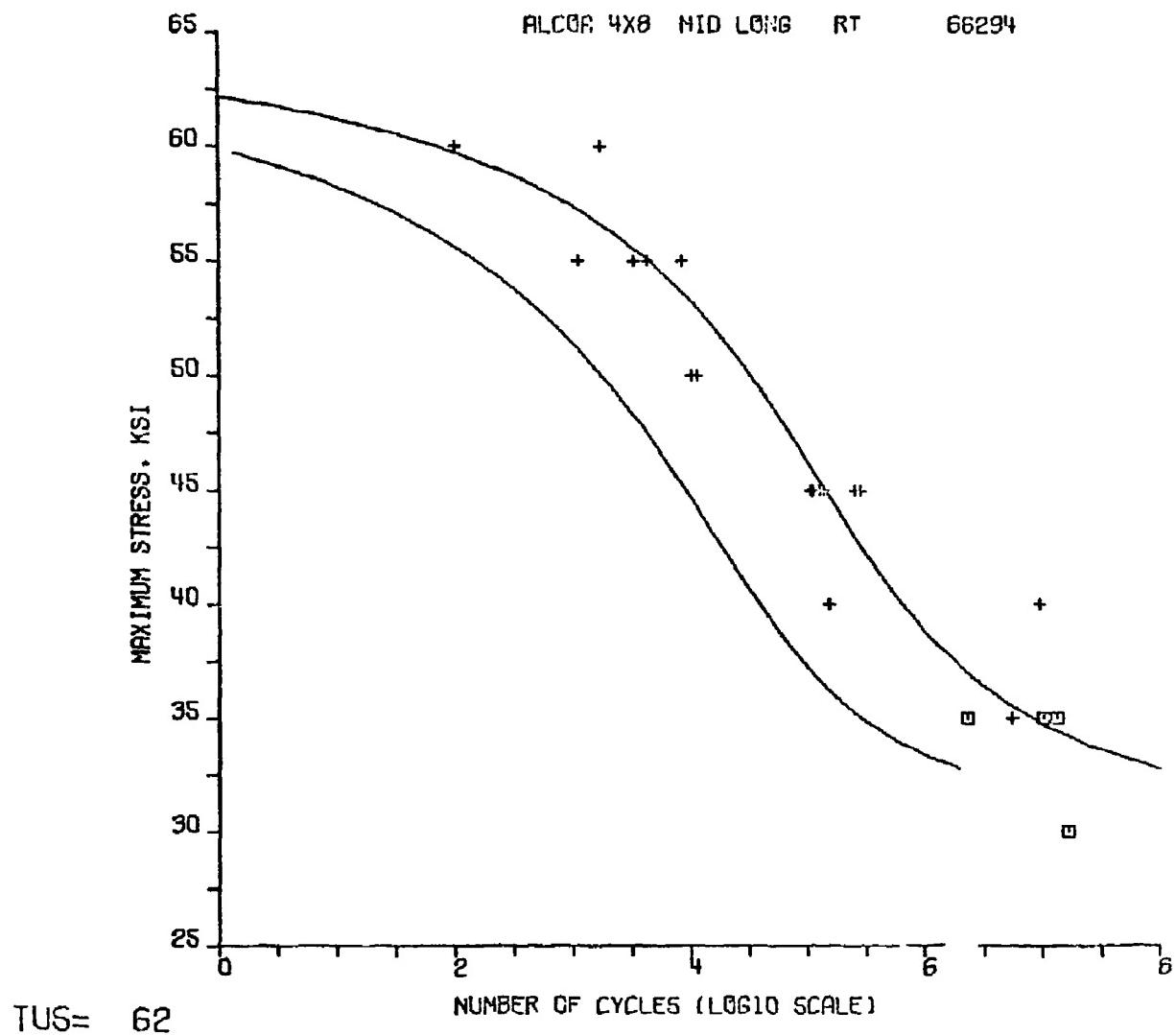


EXHIBIT 6. A COMMUNICATION EXERCISE AT THE MAN/MACHINE INTERFACE

Darby You've fit the process right back in here (qualitative filter in Exhibit 4). Someone, Jim Smith in this case, has evaluated the article and suggested it is good. If your purposes match Jim Smith's, it probably is useful. On the other hand, maybe Bill down the hall will look at the same article and because it does not match his purposes - his filter - he will reject it.

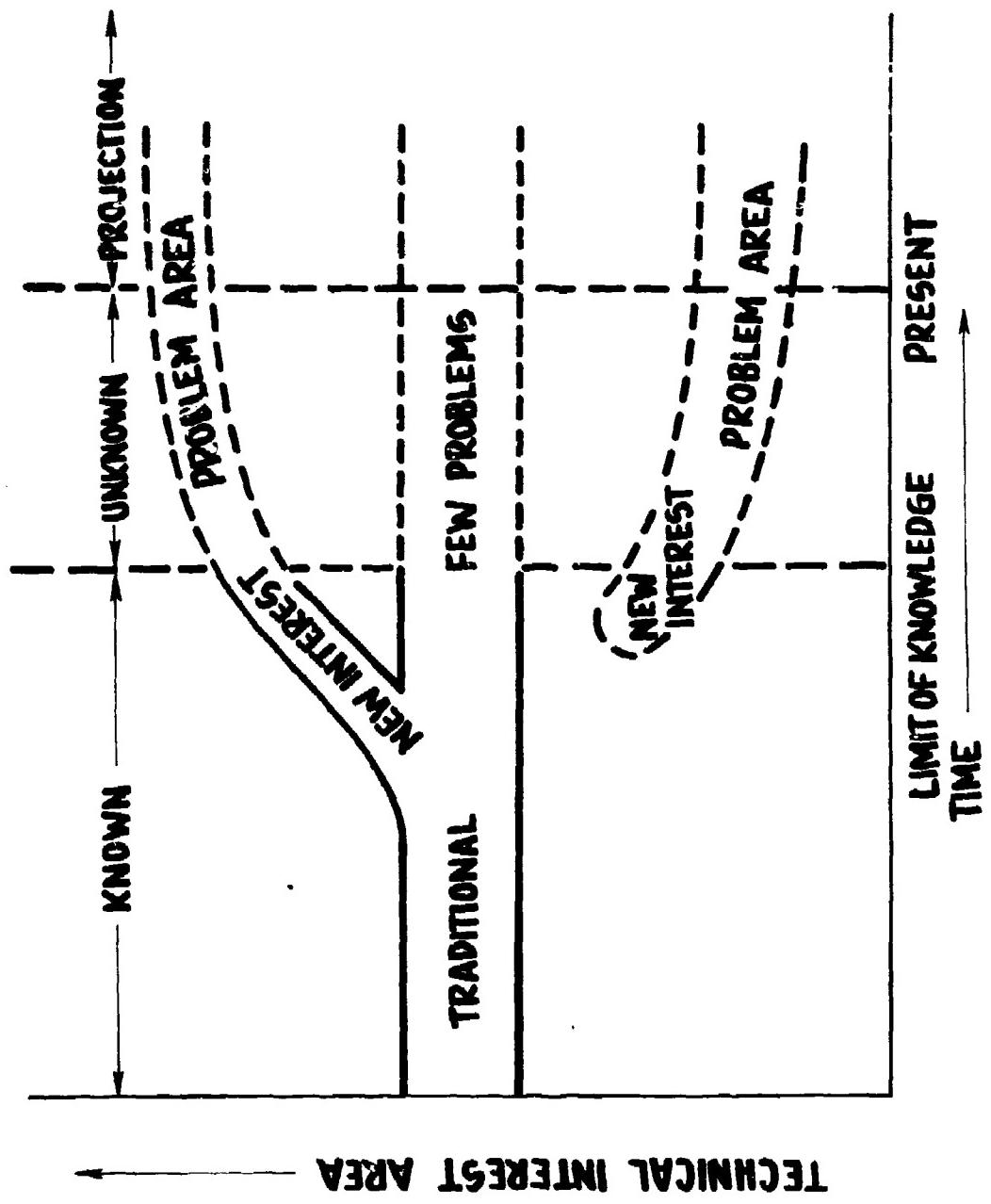
Now, one of the things that some literature people become worried about - and I hear many words to this effect - is that you're liable to miss one bit of information in one particular paper and thereby permit duplication of research. This line of reasoning happens in the STINFO circles quite frequently. And yet, this reasoning neglects the fact that no one publishes negative results. The only place we're publishing negative results, to any extent, are in the medicinal areas. So we never seem to worry about the fact that we're going to duplicate all the negative research; we only worry about duplicating the positive.

I would like to come to this next figure (Exhibit 7) because I think it relates, in some ways, to this exercise we're doing this morning. One of the things we were trying to understand in some past work was where we, as information specialists, fit into the technical community, where we could be of greatest service. Let us assume that the ordinate represents a broad technical interest area. The vertical dotted line to the left represents the present limit of knowledge, and the dotted vertical line to the right represents "today". To the left of the line is the sum of the known knowledge in the technical area and the vertical dotted line is the frontier of that knowledge. Next, let us assume that a group of men have been working or have knowledge in narrow band marked "Traditional Area". Within this area, we can be of very little assistance to the technical people. Why? Their total education, their total training, all of their experience gives them the knowledge of competency, the confidence of competency. They can continue on out in their traditional area into the unknown and beyond the frontier with a very, very high degree of confidence. However, as they begin to broaden out into new areas of interest, outside their traditional areas, they begin to encounter some problems. Here is the situation in which the information specialists can really be of greatest help to the technical man.

Quite often the technologist will jump from the traditional area into another area and there may be no apparent connection between the two areas. I think that perhaps here, straight into the unknown, is where you are working today. You are making the jump beyond the frontiers of the traditional battery. Here at the frontier is where problems begin to develop.

The way John got me into this discussion today was to ask a question: "How do you identify a technological gap or void?" In our information analysis centers, we have never identified a way of mechanically identifying gap and void in the literature. This was my answer to John. The only way that we have been able to do it is through the use of a human computer, a knowledgeable technical man who knows the field, who can analyze the technology, and who is willing to put the sweat and work into it. Do you have any comments or questions at this point?

McCallum I'm sure they do but I wanted you, if you can, to give the little presentation you showed me Friday about the information analysis center and how they're between the information and the people that use it. You recall what I'm asking about? I thought that was most informative and pertinent to our problem here.



**EXHIBIT 7. CONCEPT OF INTEREST AREA PROJECTION**

Darby In Exhibit 8, the oval to the left represents a user audience, whatever it may be. In the case of Defense Metals, it is made up of metallurgists, engineers, who are concerned with the utilization of high-temperature materials of construction of missiles and airframes; that's the scope of DMIC. The dot in the "user audience" represents a particular engineer with a problem, whether he is located in California or New York City. He wants a direct answer to his problem, perhaps because the production line is shut down, or perhaps he has to get a proposal out in the next 50 days. He may not want, or he may not have time, to review the literature. He wants a direct answer, now.

What we have done is to build up an interface of technical men who are actively engaged in research in the laboratory. These men are chosen because they match in some way the interests of the men that are in the field. In the case of DMIC, there are about 120 engineers who normally are working in laboratories but who are available if called. When the engineer in the field addresses an inquiry to the center, it comes first to the project director, who acts as the switching station. The inquiry is immediately switched to the proper technical man. At this point a 2-way dialogue is set up, not in terms of references or a bibliography, but in explicit terms of the problem with which the engineer is faced.

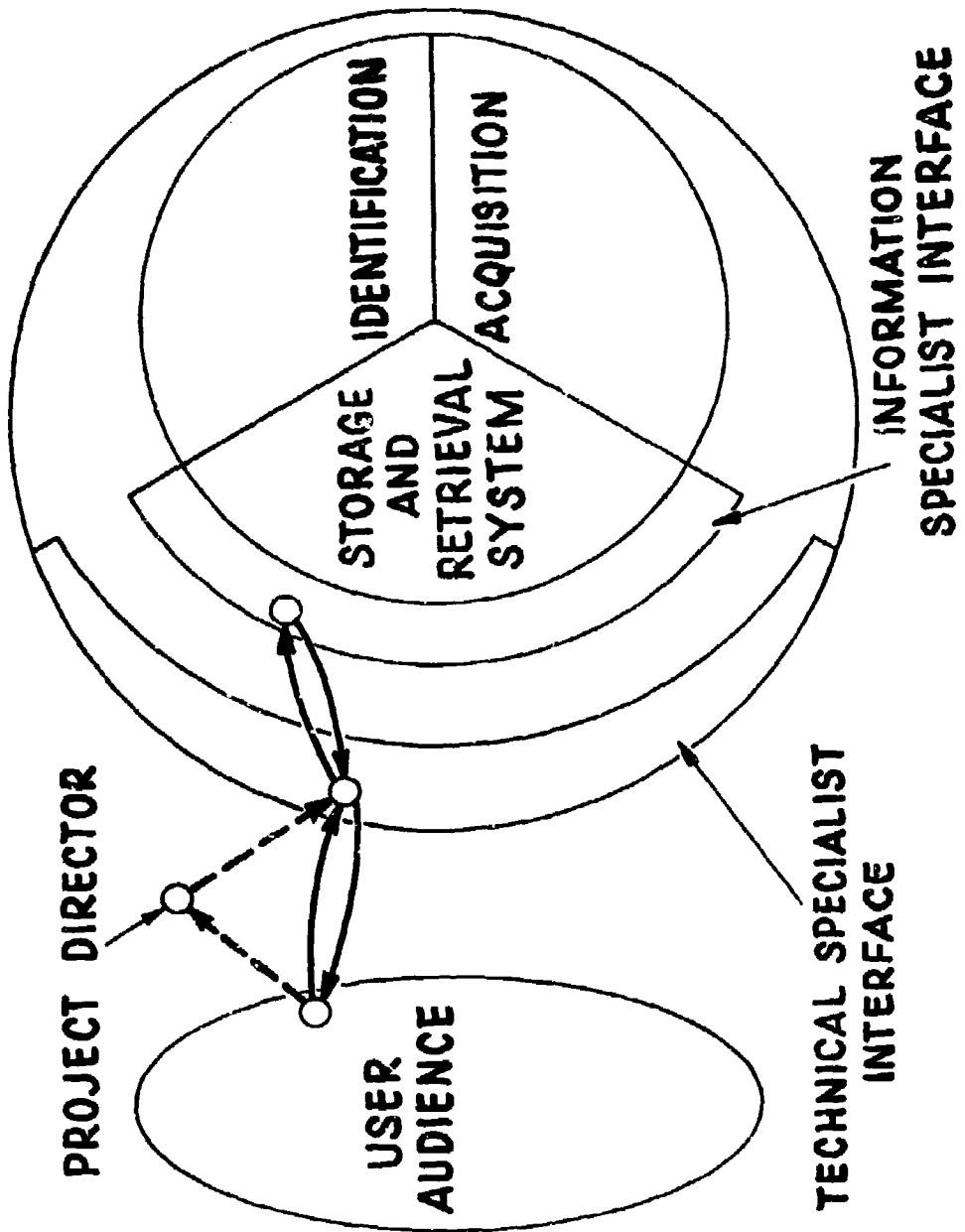
These men forming the technical interface, being in the laboratory, are very impatient with paper; they want to spend their time in the laboratory doing research or on other problems. So they don't want to be concerned with the information searching problem. What we have done is to build a second interface of information specialists between the technical men and the information storage systems. The information specialists here at Battelle are scientifically or technically oriented. They are all professional people. This requirement for technical background is deliberate because these information specialists literally become the alter egos, as far as information is concerned, of the technical man. We may assign one information specialist to perhaps up to six technical men. When the technical specialist wants information, whether from the center, the library, or elsewhere, an information specialist reacts.

So far as the information storage and retrieval system is concerned, the arrangement may be considered to be relatively unimportant so long as it is not too expensive compared to the services it renders and the audience it serves and as long as it supplies the information the technical specialist needs with a minimum of delay. The information specialists operate the storage and retrieval system. Exhibit 8 is my representation of the STINFO concept of an information analysis center. If you read carefully the STINFO definition of an analysis center as presented in the DOD instructions, I think you'll see that it fits pretty close to this; you must have interface of technical experts between the user engineer and the information. Then, all communication between the center and the audience is in technical terms rather than library or literature terms.

Faust It seems to me, Ralph, that you've emphasized the very critical importance of the human element in the memory, the skill, the experience, that backs up that memory.

Darby That's right.

Faust And that memory is the important part of the whole retrieval system.



**EXHIBIT 8. THE IAC - USER AUDIENCE RELATIONSHIP**

Darby The knowledge and the capability is in the minds of the technical men. We've found no substitute for that. However, only part of the information and data can be stored in memory. The rest must be stored in some way - usually in recorded form.

Miller The addition of technical specialists permits the information center to perform analyses functions, right? That's the major difference between information from centers and other information systems?

Darby Yes. If I take away the technical specialist interface, I have nothing but a library or an information system of some sort (Exhibit 9). In order to get the analysis into the information center, you must have this technical man at the first interface to provide the transfer link between the information system and the user.

I might pass these out (Exhibit 10). This is another form of illustrating the information analysis center. Notice especially the inputs, how far they go beyond the traditional scientific and technical journals.

Marsh Isn't the only reason you have this technical personnel at the first interface (Exhibit 8) is to interpret the man-in-the-field's request, what he's really seeking? Therefore, if you could get the engineer to use a standard language or definition, then you would eliminate this technical type of interface?

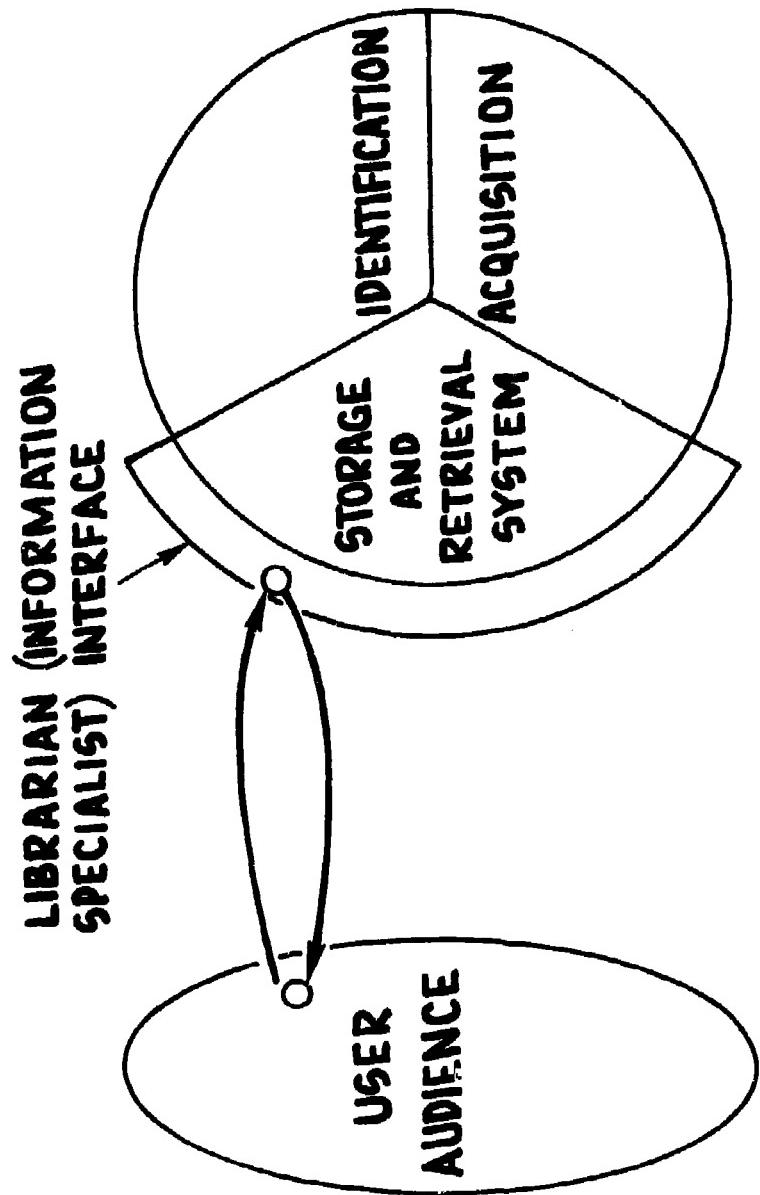
Darby No sir.

Marsh What about library people and if they had to seek the information engineers requested?

Darby Librarians would be able to seek documents and they would end up with a bibliography or a pile of documents. The answer is No, sir. The technical specialist at the information analysis center first interface is all-important. Only he can prepare a technical answer written in technical terms.

Now, further than that, this technical man controls acquisition function. The technical man decides what information or data he wants. Further, since he is receiving the questions from the field, he may also identify gaps and voids. For example, let us assume that he notices the same or closely related questions coming in from the field. He can immediately assume that there is some reason behind this large number of questions and seek to identify that reason. He might take a critical look at the available information and find a void. He may instruct the information specialist to search the library for more literature. Perhaps this nets little new information. He will then become suspicious and call some of his friends to determine (1) if they know what is going on and why he is receiving such questions and (2) if they have any information that might help solve the problem. It may be that he has uncovered a technological gap and should recommend further study or even a research program. Such feedback from the user audience to the technical expert is most important in the identification of gaps and voids which might exist in the field.

## **EXHIBIT 9. LIBRARY (DOCUMENT CENTER)**



A-2 COLOR ILLUSTRATIONS REPRODUCED  
IN BLACK AND WHITE

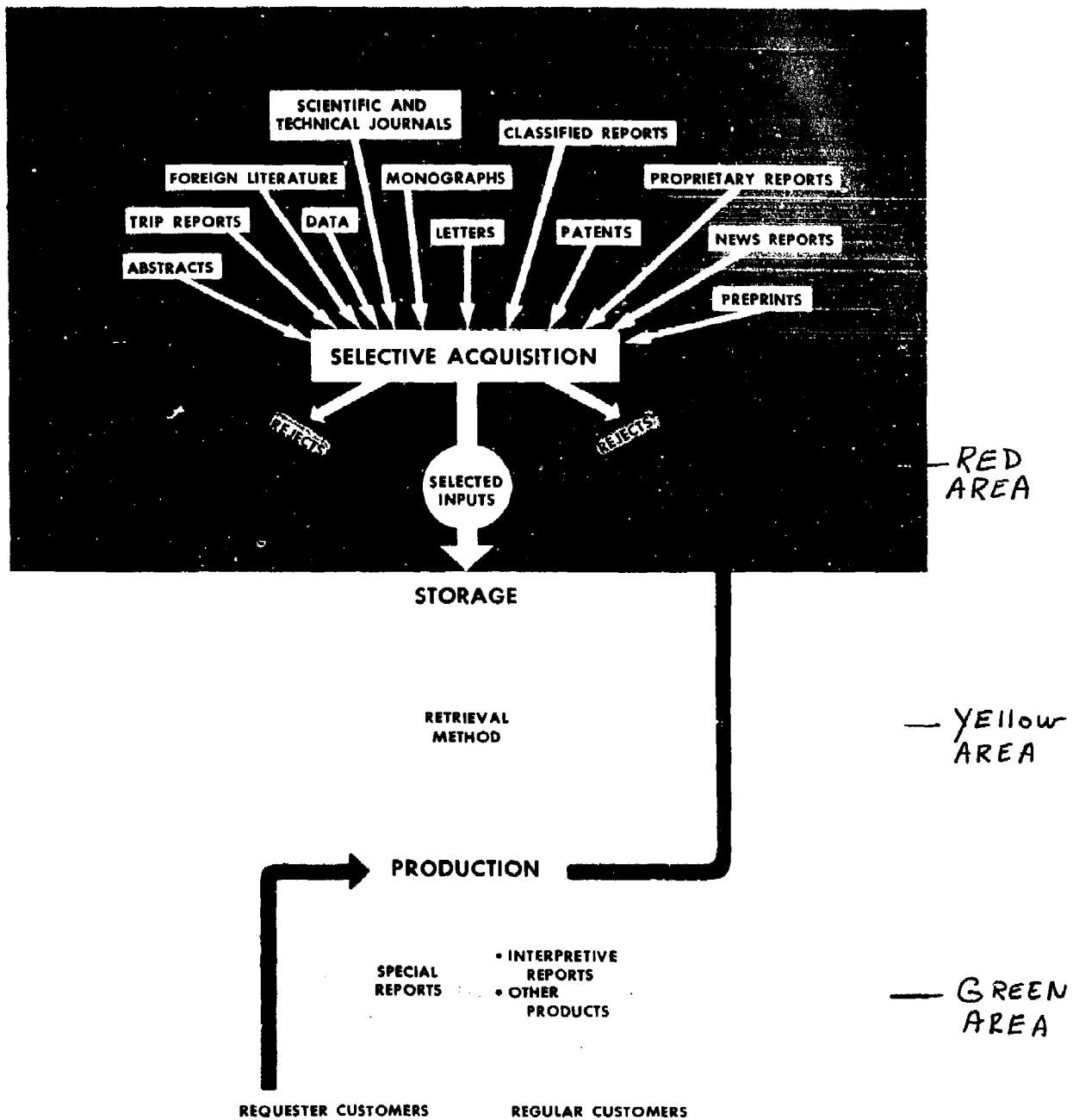


EXHIBIT 10.  
THE PRIMARY FUNCTIONS OF SCIENTIFIC INFORMATION CENTERS

Another example of the need for the technical man: suppose at the time the large number of questions came in from the user audience and assume that there was available information. The questions are a signal for the center to assemble the available information and data into a technical summary or into a state-of-the-art report as represented in the green area of Exhibit 10.

An information system or an information specialist cannot make these judgments. The only people who can make such technical judgments are the technical personnel. So my answer to you is No; this technical man (Exhibit 8) must stay at the interface between user and storage, regardless of language, or regardless of the system. The technical man is the all-important element of analysis centers.

Marsh So then, improving language may do away with the information specialist then.

Darby No, I don't think so. The technologist should be kept at the lab bench. That is where he belongs. The information specialist can form an active interface between the literature and the technologist, thus freeing the latter for his main job, research and development.

Faust Ralph, you mentioned that very few people publish negative results. What's going to happen to this pile of paper when they start doing that, because it's probably ten to one, perhaps a hundred to one, in that direction?

Darby I don't think they'll do it, sir. No. 1, the editors of the journals won't let them.

Faust Well, that's because we're all brainwashed into a system of accentuating the positive.

Darby That's right. And No. 2, the other point is most of the men like to see good positive results - "we were a success".

Faust That's the American way.

Darby Right. Now, in medicine, it is a different situation; in medicine they must publish negative results.

Linebrink But don't you find that research reports are more apt to report negative results?

Darby Yes, but the research report is a different animal than the journals. Yes, there are negative results, particularly in the monthly progress reports, but you'll find the negative results downplayed in the final reports.

Faust Sometimes that's our stock in trade. We know there are many ways that don't work.

Darby To return to Exhibit 10, the feedback loop here is the same feedback loop as in Exhibit 4. You can picture the selective filter of the technical specialist as a part of selective acquisition since he controls acquisition. The acquisition function is colored red for danger; every effort must be made to assure that the right information is going into the system. If you don't have the proper input, the information system, no matter how good it is, just will not produce the information. The storage and retrieval section is depicted in the center and this area is yellow for "caution". Some systems designers become so involved in expensive or elaborate systems that it is costly to maintain relative to the urgency or relative to the economics of the situation in which the center operates. Make sure that the system does its job; that it retrieves the type of information that the man needs in the way he needs it.

The payoff which differentiates an information system from an analysis center is the green area, and as I've pointed out previously, that's where the usefulness is. The products of the center are the results of technical analysis - not of the information system.

McCallum Well, Ralph, as I see our situation here this morning, we're a small group but we're engineers and technical people. All of you here know something about batteries and what it is we're trying to do and consequently, I'd like to have a go at our second experiment before we go to lunch. We'll be a little bit behind schedule on lunch, if you don't mind too much. So I'm placing you at "selective acquisition" in Ralph's category and with these diagrams (Exhibits 4 and 10) in mind, we've got a big flow of literature. Here it is with the 500 documents or so on the tables. Before the day is over, we should have some selective acquisition. Well, I guess some selectivity has already transpired; that's why the pile is as big as it is. And the documents are stored. But the thing we want to end up with today is a report about these documents. So, I think the time has come now to maybe take another 20 minutes, half hour, or whatever you think you need, and we're going to - yes, Dick?

Marsh I have a question. How does the STINFO group at Battelle handle results from basic research? In other words, where you have knowledge for the sake of knowledge and at the present time have no application or field use for the knowledge? Do you store the information gained from basic research?

Darby The answer is "yes", if in the judgment of the technical specialist, this "basic" information will contribute to his overall effort within the scope of the center.

Miller Does the technical man (Exhibit 8) learn of the gaps in the technology through the questions from the users?

Darby He learns both ways.

Miller Assume he is a specialist conducting investigations in a particular area.

Darby He will learn both ways. He will recognize gaps as he does his research work or as he answers questions. We have had people visiting our analysis centers and we have asked them why they've come. One man told us, "Well, I've already made 22 patent applications. Based on the way you've got your files organized, I am able to identify the information and data with which to write the patent applications."

We had another frequent visitor who, when questioned, said he was writing proposals based upon the technological gaps he was able to identify through our information analysis centers. Now, how the information is used depends on the user. I would like to understand more about this phenomenon of using the information to define the voids around which to write research proposals.

Linebrink Ralph, there's one point I run into quite frequently in the measurement technology: the information we're looking for is how was this data obtained for the reports? Often procedures are not documented, even in footnotes, yet the results are quoted.

Darby This is one of the problems of the instrument manufacturers; their brochures don't give you what you need to know.

Linebrink Well, it isn't the instrument manufacturer; it's the research people doing the work that don't tell how or don't record techniques in such a way that it's meaningful and useful.

(Everyone talking at once)

--Very few technical reports give methods or techniques in detail. It's because the instrumentation is not an academic entity in itself. It's in the majority of publications, too, and the majority of researchers are not interested in the tools; they're interested in the end results; tools are only means to an end, but that means is the thing that holds the key to successfully apply or reproduce the tests. Authors should be reminded to answer these questions: how were the measurements made? have you referenced the techniques? These additions to a report would be most useful.

Darby I think such details are one of the responsibilities of the technical society or the publisher. How you get them to assume that responsibility, I don't know.

Marsh The author is more interested in publishing the results. It can cost him so many bucks a page. Is it economical publishing practice to include procedures?

Linebrink Also, the authors themselves screen, editors screen, and the information gets down to the point where it's difficult to make use of just the abstracts, if one is looking for methods or techniques.

McCallum O.K. There are two things with the documents I've given you. One of them is about the voids and inadequacies - what should we say about these reports? What

will you say about them? The other question about which I'd like you to make some notes on your pads is this: how would you suggest finding the information in these reports a year from now? That is, how would you index the document or how would you retrieve information in it? I think indexing is probably the word I'm after here since we are indexing. How would you index these documents so that a year from now you can find it again? We can figure on lunch in 15 minutes, I suppose. We'll reconvene here at 1:15.

(Start work on documents.)

(Some discussion went on while recorder was off.)

(The following is not on the tape; comments are incomplete.)

Marsh Should we wait 3 years for final answers or feed information as it accrues?

McCallum Any experience?

Marsh Get the information out. Have a trade-off between speed of reporting and amount of reporting. Is it more valuable to wait? It's probably more valuable that the information become available as soon as possible.

(Tape back on)

Darby I think this is just what John is trying to determine today. He is supplying you with abstracts of the recent literature on batteries on a regular basis. What is the most useful depth of indexing? How do you people at Wright-Patterson or at Battelle attempt to use these abstracts? I think this is one of the things that might come out of this experiment today. While you are reading each report, you might index it from your point of view. This procedure may provide the most useful guidelines for indexing the battery literature from your point of view.

McCallum Well, indexing is one of the things to be accomplished. The other thing that I specifically want each one to do with the report I've given is to look at it and to write down what's inadequate about that particular report. What's the void? Look at it; what are some of the voids you see and what's inadequate in that specific report? We are the knowledgeable technical men that Darby was talking about in connection with analyzing the technology (Exhibit 4).

Marsh Well, it's a fight all the way down the chain of command, right down to the technician that's collecting the data. Every person will have a different selection.

McCallum You say you have that problem?

Marsh I think everyone does.

McCallum Yes, I guess I missed your first statement.

Marsh Obtaining a standard selection procedure where the information goes all the way down to a technician. He may have collected the data or plotted it using the proper labeling for his system and the technique involved.

McCallum Right. Okay --?

Marsh And the technician may be not quite that devoted to details or he may not have been required to report in detail. By the time his measurements reach the engineer, who might have 5 or 6 tasks, he labels it but it's rather sketchy. The engineer doesn't really get involved with all the measurement details so he fills in enough so that it's completely understandable to him at the time he writes. Maybe 5 years later, he will go back and - "Well, there's a lot of things that should have been included."

McCallum Right. So you think that we ought to have some organization to this report writing, some standardized terms?

Marsh Absolutely.

McCallum Well, this is the dilemma you can get into: on the one hand we want some freedom to express different things differently. On the other hand, we have to get standardized. Is it not a very real problem to ask for freedom of expression while holding to standardized expressions?

Marsh The researcher wants everyone to understand his work and to gain from his work. Isn't that correct? Now, in normal procedures he may coin new words or give new meanings to old words and soon no one can understand him.

McCallum One thing that defeats you with a thesaurus or standard term might be illustrated by talking about the battery term of "shelf life". Now, you'll find that, if you could get everybody to use that term, then if you look up shelf life as you make a search, you may be led to 500 documents about that and you're swamped.

Marsh Well, then, you have to have subtitles; shelf life pertaining to what? That's one of our problems in going to STINFO in our laboratories; we discuss with the STINFO person our problem, and they try to get an understanding of the information needed. But now there may be 5 or 10 terms that you're familiar with yourself that describe the same thing. Then, who knows how many other terms have been coined in describing it and how does the machine separate these many choices of words? If you're looking for "oxygen-consuming electrode" or "charge control devices" and the title of the paper is "Adhydrode Characteristics", a machine can't decipher that title and say, well, this pertains to "charge control" or "oxygen-consuming electrodes".

McCallum No. We ran into a word problem with these machine searches mentioned previously by Mrs. Johnson.

Marsh So, information retrieval is always going to be a complicated system until we have a standardized terminology. Maybe if a survey was published with coined words, it might be beneficial; at least such an attempt might encourage some of the battery manufacturers that we're involved with to try to use standard terminology.

McCallum Okay. Well, are you saying that you couldn't index this document in front of you unless you have standard words?

Marsh Well, I'd have to index it in my terminology since there's no standard terminology.

McCallum This is exactly what we do at Battelle, and it's done for that reason. Darby could comment on this better than me, but indexing and card filing has been done that way with cross-references, with words that the engineers themselves pick out because that's the way they retrieve it. One engineer may like to file under "anhydrode" and another may like to file under "oxygen". So you let each one file or index it the way he wants to, and in that way each can go back and find it under his own word.

Marsh So then, that is the main problem - technical people are such independent characters?

McCallum No, it isn't that. It's just that if you don't provide such freedom, you may end up with a beautiful system that nobody uses. It could be the greatest organization thing you ever had, with everything in a neat little place. But nobody uses it, and that's it.

Marsh Well, I don't see how you can really go back to that analysis because the standard system has never existed, so you can't really tell whether anyone will use it or not.

McCallum They've tried to make it exist and it doesn't get used. It's like going back to these machine searches from DDC. They have neat little keywords, descriptors, that you can go to, yet you hesitate to go back to that thing again; you get swamped.

Marsh The reason you get swamped is that maybe 99% of the DDC reports you receive have no bearing at all on your problem and it may be because of the language. You can't define your problem in everyday language.

Faust I think what you're asking for is what the lawyers have established. They have established by court test what each word or phrase means, so whenever it's used it has an established meaning. Only because they set out to make it be this way.

Hardy You see how readable their reports are as a result.

Marsh If you were a lawyer, familiar with the language, it might not be so bad.

Faust That is at least one way to take care of an expression: to establish the precise meaning for it.

Hardy I have a question. What definitions of voids and inadequacies would you like us to use on this? Mine won't work. I can't use my definition with one report because a void or inadequacy must be considered in the total context of published information.

McCallum Exactly. That's why Darby emphasized the man in the middle of that Information Circle (Exhibit 4). We are supposed to be the experts with the memories that allow us to evaluate as we read.

Miller I'm wondering if the problem at hand, to define voids and inadequacies in these two technologies (Ni-Cd and Ag-Zn batteries), comes about because we do not have the benefit of this team of technical experts (Exhibit 8) to help analyze the report data. I'm wondering if the information specialist and retrieval system could provide not only abstracts from reports but also a condensed (extracted) form of what is in the report. The condensed form will assist the technical man in making an early judgment whether or not the report has potential valuable information and therefore should be examined more thoroughly. I feel there are additional bridging jobs that the information specialist must accomplish to better prepare the technical man for screening and analyzing the literature.

Hardy Where do you see us up there (Exhibit 8)?

Miller We're in the technical specialist interface.

Hardy We're there and we're out here too in the users field. We're the ones who are both an interface and a user. So this is where our dilemma lies.

Marsh The way I see the group here today is you're the information specialists. You screened the material that's here now.

Hardy No. We're the users.

Marsh You're the users, but you're also the information specialists.

Hardy No, no. We're the user and the technical personnel, not the information specialists.

Brooman But we do screen some of the literature possibilities.

Marsh Yes, but someone sends you the reports, has you abstract and select key-words, and so forth. Therefore, you're an information specialist.

Hardy No, that's the function of the technical person in this diagram (Exhibit 8).

Cover That's within the information function.

Marsh I thought it was the information specialist's job to provide the technical man with material pertinent to his problem. He screens the material before entering it into the system or using it.

Hardy Well, okay, there is some overlap. I guess you're right that, under a rather strict definition, the information specialist uses the keywords and selections that the technical person tells them to use. In our case we do some of this, so that we're falling in all 3 places (Exhibit 8).

Marsh Because there're no clearly defined keywords?

Miller We on this program must generate certain questions, screen the literature to determine if information relevant to the questions exists, and lastly analyze the information to determine if the questions are adequately answered. I think that we'll have to inform the information specialists of our interest areas within these two battery technologies. We should permit them to screen the documents rather than just provide the abstract.

Hardy You're asking for an analysis function.

Miller No. What is intended is to have the information specialist extract or condense the documents against a list of questions or interest topics submitted by the technical man. The technical man would then analyze those documents the information specialist indicates as probably pertinent.

Marsh Well, this duty belongs to the technical type according to the definition up there (Exhibit 8) and they should be able to analyze.

Miller We don't have this case here, though.

Hardy Information specialists are not the technical men. Strictly not. Your suggestion is quite reversed because they aren't supposed to introduce any changes in information. Information specialists can extract.

Marsh To extract pertinent information, they would have to be able to analyze the report.

Hardy Not necessarily; all they have to do is be able to interpret instructions from a technical person as to what should be extracted from reports.

Marsh So, then, that's where you get the problem of communicating.

Hardy Yes, you're right. This is where you can lose material; if they don't understand what you need, then it doesn't get into the system. Yes, you're right.

McCallum Well, I'd still like to have you take a sheet of paper with this report you have in front of you. Either index it, or make a note that you don't know how to index it, or you're not going to, and give me a reason, or something. Give me some help here in where we stand with regard to retrieving this information. The second thing I want is on voids. And if you say, "I can't tell about the voids", okay, you can't tell about the voids and that's your answer.

Faust Don't you have 2 kinds of voids to be concerned over, John? One is the void in a single document as regards meeting its own specified objective; another is a void in an area of which this is only one document and you have to review them all for their objective.

Hardy Right. This is where my definition was, as far as my understanding of what we were talking about.

Faust You can't look at one report and say, "What's a void?", because it might meet its complete objective. There are no voids in it as a single objective goes.

Hardy We're talking, then, about the adequacy of the report itself as a report.

Faust As a report with its own objectives.

Miller This is why I'm thinking we should designate particular categories within each of these battery technologies. Reports that fit into the particular categories would be analyzed and, therefore, a more definite statement could be made: "Here's a void or inadequacy in this category of this technology."

McCallum Okay, put your notes down here. If that's the way you assess the situation, then that's the way you've assessed it. The reason I'm doing it this way is that I learned from Darby's talk - he's the expert on this sort of thing - that there is no machine way. There is no automatic way to go get a piece of information or to point

out a void. He doesn't know exactly how to do it even though he's been trying for years and has had the best minds in the business trying to find out how to do it. His prime suggestion was that you get a group of experts, technical people who are in a given technical area, and they do it. They tell you that there's a void or there isn't a void. That's how we are to analyze the literature, because I don't know where we could put together a better group of battery experts than exists right at this table.

Hardy When I seek data or information on one specific item, you send it through your machine and you don't get any reports back. Isn't that a void?

McCallum You might just wonder, did I pick out the right words? Perhaps you just didn't ask the machine the right question.

Marsh We shouldn't have that problem. In other words, negative results could be interpreted as a void, or as the possibility of a void. In other words, a given document may be more pertinent to some big problem, but it's not pertinent to your immediate question. Or perhaps words were not defined in the manner in which you were defining them so, therefore, it's just a matter of communication.

Cover That's an inadequacy in the terminology then, which is one of the things you want to point out.

Marsh Right.

McCallum Well, I agree that terminology is one of our problems. We've got quite a few problems, obviously. But one of our problems is that you pick up a report like this and, assuming we're as close to experts in the field as we'll find anyplace, the one way to tell is this adequate or does it have some voids is to use your own memory device. You've got your own computer up here (in the head). We all vary, but you're going to have to judge this document before you on the basis of what you know and point out to me a void, or an inadequacy, or write down that your computer doesn't work that way.

(Back to work on documents)

(AFTERNOON SESSION)

McCallum Well, I don't know how far we got on the first experiment on the documents, but how are we going to work this, Dottie? We were going to do this again another way, but how do we get the first results? Do you have them?

Johnson We can hand these report analyses back and let them turn them over and try again and mark them 1 and 2.

McCallum During lunchtime, Jerry brought up the question about voids and inadequacies and what might happen if we were to inquire of some of the recognized experts in the field, like Lander on silver-zinc or Fleischer on nickel-cadmium batteries. If you were to ask them about the voids and inadequacies and select a dozen or so men who are recognized in these various areas, maybe we would end up with a consensus of what voids and inadequacies are. That's another thought to toss into the record here.

Linebrink You mean a definition of voids or what the actual listing of the voids would be?

Miller What these authorities feel is lacking in the technology. Perhaps we could tie them down to some fairly specific comments, and use the comments as a means to screen our own literature.

Linebrink Well, recognized experts certainly have a background of experience, but - .

Miller In some cases, though, a public disclosure might tip their hand on what they consider proprietary for their own research program, although I'm not sure.

McCallum I might mention a personal experience I had with one of the battery manufacturers. When he heard about this job, he said, "What are you doing in the silver-zinc business?"

I said, "Well, one thing we're doing that may interest you is measuring some silver solubilities."

He said, "My word! We did that a number of years ago. There's been a number of measurements of that."

I replied, "That might be. But there are a few voids, I'm told, and some discrepancies among various reports. But even so, we might be getting into the rate problem. That is, not only how soluble is silver, but at what rate does it dissolve?"

"Ah," he says, "that's another problem. We looked into that, too, and it's too complicated."

So, on the one hand this expert is saying don't study silver solubilities because he knows all there is to know about it. And on the other hand, he's saying don't study solubility rates because you can't accomplish anything; it's too complicated. This little story, I think, illustrates a problem we might have with an inquiry. I don't know that it's an insurmountable problem, but it's certainly something we can think about.

Does anybody have any comments left hanging in the air that you want to put on the record here before we proceed? It's for our own use, you know. (No comments.) Dotties, do you have any comments you could make about what happened this morning on the questionnaires?

Johnson I can give you a partial summary because I'd like to have more time to go over them. But on Question 1 (see Exhibit 2) we were interested in the methods you normally use for keeping aware of developments in your own field. The questionnaire was filled out by 11 people who listed 34 different ways of doing it (see Exhibit 11). This large list is most interesting, and perhaps it might have some bearing on Murdock's statement about the methods of retrieval never being duplicated in 10,000 cases. The next question was on voids and inadequacies (see Exhibit 2), and again the results were very interesting (see Exhibit 12). I think that within the definition of the words everyone seems to be in general agreement of what we're looking for, although I think a problem still exists on how to define those problem areas. Everyone seems to have expressed the same thoughts in different ways. Yet it seems like this subject is a very personal question to each of you from the standpoint that if you need information and you can't find it, no matter what that information is, it's a problem and a void or inadequacy. Now on the third sheet (lines 4 through 7 in Exhibit 2) we were interested in discussing the subject index, and I can see from the answers that the accession lists and indexes are being used. Half of you have had successful experiences and the other half have had some favorable experiences and some not so favorable, which is exactly what we wanted to find out. Your suggestions for solving some of the problems that we have with the indexes should be most helpful. Most of you have requested that we consider either deeper indexing or identifying the numbers as to their subject content in the author or facility indexes. We will keep these questionnaires and certainly use them, and perhaps we can help each of you a little bit more efficiently so that all of you may have successful experiences with our final system. I think that that's the general impression at the present time.

McCallum One of the questions that came up has to do with how a controlled vocabulary and a thesaurus might help in retrieving information or in judging reports; if you had words with well-defined meanings. Did I word that right, Dick?

Marsh Well, if the reports had words with well-defined meanings; right now they do not exist as such. So in the future, I don't know whether we'd be able now to assign a definite vocabulary because the literature doesn't have any. A thesaurus might help the people searching for information get an idea of what to look for. In other words, like the third electrode: it has 4 or 5 different terms that I know of and there's probably more, and how does the librarian or whoever it is pick out articles pertaining to that?

EXHIBIT 11. METHODS LISTED FOR KEEPING AWARE OF DEVELOPMENTS  
WITHIN INDIVIDUAL AREAS OF INTEREST

- 
1. -Rely on others
  2. General discussion
  3. Write a paper or report
  4. Card file on books
  5. Battery accessions list
  6. Review journals in main library
  7. Main library New Books accessions sheet
  8. Chemical Abstracts
  9. Machine literature searches from Government agencies
  10. Review circulated technical journals
  11. Review patents
  12. "Brain-picking" consultants, fellow workers, competitors
  13. Technical meetings
  14. Salesmen
  15. Trade shows
  16. Destructive analysis
  17. Maintain card file of abstracts
  18. Review abstracts
  19. Use services provided by an information facility (STINFO, WPAFB)
  20. Personal subscription to technical journals
  21. Fuel Cell Information Index at Battelle
  22. Battery Information Index at Battelle
  23. Instrumentation Files at Battelle
  24. Manufacturers literature
  25. Follow work of researchers in the field
  26. Transactions of technical groups (IEEE, Chem. Soc., SAE, etc)
  27. Technical Accession List prepared by WPAFB
  28. Abstract bulletins distributed by Government agencies
  29. Don't have a good method
  30. Information Research Center at Battelle
  31. Newsletters
  32. Commerce Business Daily
  33. Project Briefs from Power Information Center
  34. Engineer conferences
-

**EXHIBIT 12. WHAT IS MEANT BY "AREAS OF VOIDS AND INADEQUACIES IN NICKEL-CADMIUM AND SILVER-ZINC BATTERY TECHNOLOGY"?**

1. Areas in which explicit information about known phenomena or data is not available.
2. Areas in which no data is available.
3. Areas in which a compilation of scattered data would be useful.
4. -- For established battery systems, some areas of technology either are undescribed, or have unsolved problems, or both.
5. Areas in which answers to questions are not known or at least are not documented.
6. The technical problems which have not been solved or whose solutions have not been given in the literature.
7. Lack of available documents which clearly define or qualify facts related to design, production, and use of Ni-Cd, Ag Zn batteries. Some state of art is purposely concealed, other information may be classified. Other literature may suffer in context by not writing to the widest audience.
8. When someone asks me something to which I can't find an answer, that's a void.
9. An inadequacy: poor descriptions of what was observed.
10. An inadequacy: lack of interpretation - no mention of what was learned or how.
11. An inadequacy: lack of understanding of how to use the data. "So What?" - is not always answered.
12. Battery data, basic type data, is somewhat deficient in nature with respect to defining the overall system.
13. -- Areas in which there is no data or material published but available or areas in which there is no data and material available. I think of this as two problems, one of published material and the other of known facts.
14. Lack of specific information to adequately explain observed performance, either good or bad.
15. Lack of specific information on cause and effect so that shortcomings can be corrected.
16. Lack of techniques for associating performances with electrochemical and structural changes as they occur.
17. Void areas - those areas in which no data or previous work has been conducted or reported. It may be a portion of a total system that remains to be defined, or it may be a new approach to analyses or interpretation.
18. Inadequate areas - those areas in which limited data exists, or the data reported does not accurately define the actual case. For example, basic assumptions in certain thermal analysis work are not accurate, therefore the value of the analyses are questionable.

McCallum Dottie, do you recall some of the problems we might run into? I think I commented to Dick at one time that if you get your word defined so that everybody starts using it, then if you go back later and punch that word, you end up with too many references; you're swamped with them. His answer was, well then you need some subwords and subcategories. But then you may have the problem "Well, I went into my subcategories, but I didn't find what I was looking for; I wonder if I went into the right subcategory?" Then, Dick's answer was, "You can't say that good vocabulary wouldn't solve such problems because there isn't any such thing; no one has had the perfect vocabulary." What are some of your reactions to such remarks? I know that we've talked about this fitting a system to the engineer versus fitting an engineer to the system. I also commented during your absence this morning that we could have the most perfect system in the world, but it won't do anyone any good unless it gets used. Dick's good reply was that you can't tell whether it will be used or not, since we've never had the perfect system. Would you care to speak to that?

Johnson I think we have the possibility of selecting two extremes. One extreme, to me, would be a fixed thesaurus, from the standpoint of a controlled vocabulary. You might actually be setting mental fences for the engineers, and you feel like they would have to learn a new language in order to use the system. Now, at the other end of the pendulum, you can have a situation in which every engineer can use the word that he wants to use or term that first pops into his mind, and then, of course, you'll have your third electrode, state-of-charge indicator, and so forth. Now, this particular situation could be controlled through the use of a great deal of cross-referencing, such as "see also" cards. There are people who object to using "see also's". It's just a personal offense to them and a disappointing fact that they may have to look further. Somewhere between those extremes could be a system that would lend flexibility and yet imply some discipline in the use of the words. So I say either extreme is very bad and could result in an ineffective system.

McCallum Do you know what Chem. Abstracts does in that regard? I, at one time, intended to bring down a recent issue of Chem. Abstracts, Section 77 I think it is, where you find electrochemistry. In that one thin section, as I recall the numbers, there would be, every two weeks, about 300 columns of abstracts and there would be some pink sheets at the end. There would be 100 columns of words indexing 300 columns of abstracts. This relationship kind of snowed me. Here's 100 columns of words I have to consider on where to look to find where certain information is to be found in 300 columns of abstracts. And this goes on every two weeks! I guess my original question was whether Chem. Abstracts looks upon their index as some kind of thesaurus. Do you know if their indexers memorize those keywords and they keep using them over and over and over?

Johnson I have not talked with them. It is my opinion that they must have some format and some discipline in their choice of words.

McCallum I know another problem you've run into is this: you ask an engineer to key in this document. He looks at it and he doesn't give you a word; he gives you a phrase - "electrochemical evaluation of electrodes". So, what are you going to file it under? - electrochemical? electrodes? evaluation? You could criticize the words, but the point is that if an engineer will give you a phrase rather than give you a word,

how do you cope with that problem? I was having trouble with the document I was looking at a while ago. I found I wanted to use two words, a combination of words.

Johnson I would say this has worked out in the past through interpretive filing. An information specialist reads a phrase in the context of what the document is trying to tell us and then files it in the most logical place.

McCallum The engineer won't decide what's the most logical place, is that right?

Johnson That is right, as far as the exact filing position within a category is concerned. The concept of the phrase selected by an engineer is never altered, although the physical position of the words may be changed. There is always a problem with certain words, especially when you get into electrodes and similar words which recur frequently. Some clerical liberties may have to be taken in filing procedures in order to maintain the usefulness of a system and eliminate overusage of certain terms.

Linebrink Your own logic won't reproduce from one day to the next the same keywords.

Johnson But this is what's done; it has to be --

Hardy This is the thing Darby was saying about selective acquisition; someone has to make what seems to him to be a logical decision.

Linebrink But under your own logic, even if you're going to retrieve the things that you've filed yourself, you may not think of it in terms of the keyword that you thought was the only logical keyword to have used the first time.

Johnson Actually, we have two systems here in action: one in which technical men assign the keywords for filing and another in which I select the words.

Linebrink So, you need to have some cross-references. I think that's the only way. I don't think there's any real gain to be had other than understanding this problem because I think it's one that's inevitable, we're going to have with us and, as Dorothea said, something that avoids the two extremes and is flexible and usable is the one that will be used the most and give the most results to all concerned.

Hardy This is the thesaurus approach?

Linebrink No, not necessarily. A hybrid with cross-references. For example, I've been interested in filing instrumentation literature and information for quite some time. Manufacturers' literature is one that most librarians won't touch and yet it's the most current information that we have in many instrumentation areas. I found

there that to file by subjects doesn't always fit; trade names get inserted in this also. We do use two systems: (1) a company reference and (2) a subject reference. We also use plenty of indices to the instrumentation literature made up by various people. These are subject indices and cross-referenced with companies and, in some cases, authors; most places, companies. If we want to take a quick look, we'll look under the subject file. If we want to go more in depth, we'll look under a cross-reference that tells what companies make certain types and then we start digging into a company file, and usually we can find things that are pertinent. So, the question that always remains is, do you have in your file the most important thing that might be in existence somewhere on your subject? And I don't know the answer to that question.

McCallum How are you finding this information in the first place? I think we came around and asked you about pressure transducers. Now, do you have an index you turn to, a card file, or do you ask your secretary?

Linebrink We have one file on transducers. This would be the first file that we would pull out.

McCallum So you go right to the documents.

Linebrink Yes, and look through them. We have to file the documents because we can't abstract manufacturers' literature very well and if that didn't yield sufficient information about transducers, we would look in another index that tells us what companies make pressure transducers and go to those company files. Now, we might not have in our file information from all of the companies that are listed in various indexes. Then we would start looking around. Well, are these prominent companies? Should we supplement what we already have by making the equipment from components? And this way we build up our information. We may find the answer you're looking for in the very first grab that we make, if you're fortunate. But this searching is a continually changing picture because of the new developments and new inventions, new company advertisements or brochures. But much of this company literature is related to technology that is even 6 to 12, 18 months ahead of the technical articles.

Hardy I'm sorry I got here late; what was your specific inquiry here in relation to? I had a couple of thoughts in an area that related to our indexing and possible ways of retrieval; is this what you're after?

McCallum We were just talking a little bit about what Dottie found out when the questionnaires were filled out and then we brought in some of the subjects we were discussing just before lunch about controlled vocabulary.

Hardy Well, this could fit in with that in a way. I was just wondering if the acquisition list doesn't really serve to give as much information as it might. It's a very compact form, this Monthly Accessions List in our system; I'm speaking now specifically about our system here; we have a limited number of documents - not ten rooms full. In going through this report in front of me this morning, the thing that struck

me was I can put down keywords, but of more importance is keyword groupings because - this touches on the problem you found - this particular report is on investigations on the transport reaction process occurring within silver oxide-zinc batteries. If the subject matter of this report were submitted to a technical publication or scientific publication, I'm very sure that the editor would say, okay, one article on decomposition of dissolved silver oxide and then somewhere else an article on zinc electrode processes. In other words, in these reports which comprise a large number of the entries here, we have multiple subjects.

Now, in the index, there's no way of knowing, I'm sorry, in the subject index, there's no way of discovering when you see zinc oxide there, just in what context the entry was made. This ties in with the problem of trying to limit the number of entries, or the number of references after a given entry. And what I thought was that if those numbers stay in the subject index, like for failure mechanisms or something of that nature, where you have a topic with a large number of references, then on the accession list we should put the groupings of keywords that were picked out of a particular document. In other words, I've picked keywords out of this document on silver oxide-zinc batteries that is divided into two sections. Keywords from one of the sections would be silver oxide, solubility, decomposition, surface active agents, and zinc oxide. Maybe you wouldn't want all of those words, but at least 3, or possibly 4, of these would give you a definition of the area being described. Another section of the same report mentions zinc electrode polarization, amalgamation, and voltage sweep. This second area is entirely different from the first area. In this grouping, maybe you'd have to limit it to 3 words. In the accession list, these word groupings for each section of the report could be parenthetically set off. When confronted with an entry in the subject index having a large number of references with no indication of points of reference or subject association, it would be a lot easier to turn to, say, Reference 39 in the accession list and see the related keywords. Then I could see what Reference 39, listed in the subject index, refers to and I wouldn't have to scrape my fingers going through and pulling out each separate abstract card to determine the context of each keyword and reference number. If I could see the keywords associated with a given reference number, it may enable me to eliminate all but three of the listed references. I've introduced another step, but it seemed to me, just thinking about it off the top of my head, that I might be more willing to go from there (accessions) to leaf through here (cards) than I would be to dig through here (indexes) and then look at the abstracts (cards). From the cards, we might eliminate further, maybe making the system too complicated, but keyword groupings is a thought.

Linebrink I have an illustration along that same line and I'm in agreement with what Bob says. The title of this one was a final report on development of manufacturing methods and techniques for the production of improved alkaline batteries from Yardley. Well, from the title, manufacturing methods would be the outstanding thing that would be a subheading, but in looking through it, there are techniques and production tests. I even see something here about the use of sausage casing for separators. So, there are materials. All of which are involved in sections of this report about manufacturing methods. Such specialized information might be lost unless some additional keywords accompanied the title or unless that title just happened to be intriguing enough that you went to the abstract to read it.

Hardy But if you looked under sausage casing in the index, or separators might be an entry, hopefully, you might find that report. On the other hand, if you have 25 entries for a given word, it would help to narrow the search down by going back to something else, such as the keyword groupings.

Brooman Why don't you just forget the official title and list the document according to keywords?

Hardy I think that probably you're right because I was thinking, this report describes an investigation of the transport and reaction process occurring within silver oxide-zinc batteries. Now, really, there isn't a great deal on transport; there is on reaction processes; but the report emphasizes silver oxide-zinc batteries, and there's not even a remote relationship, other than the materials involved, between the content of this report and a piece of hardware. Nevertheless, the report was written for the battery technology division; that other report mentioned by Linebrink was written for the manufacturing methods division, so they may have wanted manufacturing mentioned in the title. I imagine such influences occur in such a way that, as you said, titles are not indicative.

Brooman There wouldn't be a lot more work involved in doing it this way (with keywords) because the subject index would remain the same and the filing system could remain the same. It just means that each month we perhaps have 3 times as many little short titles.

Johnson Your suggestion would require feedback from you technical people on a continuing basis. Do you believe that we could possibly do this on a monthly basis?

Brooman Well, how many documents are we receiving each month?

Johnson Between 30 and 40, I believe, at the present time.

Brooman Could you not split them up into batches, say, you might take 5 documents in my field, send me 5, and I write up keywords; 10 might interest Bob over here, so you ask him to supply the keywords. Then all you would have to do is prepare the lists from our keywords. It doesn't really matter what this title is on the document because, as Bob says, they're rather misleading anyway. In the same way, supply the machine searches to us; we go through and say we're interested, so that's one system procedure or we could also sift through the literature and provide the keywords.

Johnson And at that time, you could provide your analysis of the paper and as such you will have indicated that you have accepted it into the system. Then it would be processed in the normal manner.

Brooman Yes. That's provided that the number of papers and articles per month doesn't become excessive. At the moment, it looks as though we might be able to manage it.

Hardy Perhaps like the Fuel Cell Information Index. How did that work? It seems to me you always had to be beating people on the head to get documents back, at least me.

Johnson Feedback is pretty hard to get from some technical persons.

Linebrink The number of documents circulated may not be as important as how fast they are circulating.

Hardy The point is, you do have them indexed to get them into our system, but you don't index them at the same time that you access them, necessarily.

Johnson Not at the present time. They could be.

Hardy What I was thinking is the words that are used for indexing could be grouped and used in the accession list. That means you do the work.

Cover Well, to help Dottie get off the hook, I suggest that the technical people should go on the hook for extracting the keywords, and I think that at this stage we may have to have a common vocabulary or glossary rather than an extensive thesaurus. I think my objection to going to the abstracts on the cards is that the technical keywords in the index are different than I find on the abstracts. As Orval and I went through the same report, we found a lot of material in this Yardney report which is not related directly to the title or directly to most of the abstract so that I think the scope of the paper should be defined by a technical person who in turn should define the technical words that are necessary or technical phrases which could also provide a comprehensive coverage of the scope for the accession list. Then we'd have the technical phrases extracted by the technical person that in turn were related to the actual scope of the document. This way the technical person might actually reject the document as having insufficient value related to the scope of the paper. Also, he may see another technical aspect indicating that someone else would actually review the paper when the subject matter was different than what was implied by the title. So it may be that you turn it over to someone else. I think a judgment of the qualification or an analysis has to be injected, maybe before the document is added to the accession list.

McCallum Well, let us carry on now with another approach to working with information. I think I have talked to everyone here about my scientific definition of science. I brought it up at the meeting last Thursday. The concept is brought up again because I think it is relevant to the points being discussed. I'm referring, you will recall, to the equations:

## EXHIBIT 13. THEOREM OF SCIENCE

$$\begin{aligned}\text{Work of science} &= \text{observation} \times \text{prediction} \\ &= \text{growth of its distribution} \\ &= \pm d(\text{uses})/dt\end{aligned}$$

Today we have been touching on one of the most difficult problems of scientific research. Namely, the use of words. Scientists like to think they are unemotional and objective, using precisely defined words with units of measure. But what we like to think we are and what we are indeed can be quite different. For example, just the mention of the above equations brings up some common words which may or may not be relevant to our present discussion. How can you tell?

Well, the best way to find their relevancy is to be unemotional and objective about the equations and the words used. Let us then define what is meant by the words. Let us assume the equations are true unless proven false and, finally, let's check them out with actual experience. Those are easily stated requests but they are evidently difficult requests to grant because people seem to be able to find all manner of problems with the above equations. I recall last Thursday, for example, that one of the men riding back in the car said one of the big drawbacks to those equations was that work is an emotional thing. "Work depends on whether you like it or don't like it", he said, or words to that effect.

That remark brings us to the first rule for being scientific about science:

## EXHIBIT 14.

## RULE 1: DISTINGUISH BETWEEN SCIENCE AND THE SCIENTIST.

We might define a science with some rigor while retaining great problems about agreeing who is, or is not, a scientist. This equation for the work of science can be given meaning so long as we limit our thoughts to what the science is - whether we like it or not.

Before going on with the development of that work equation, we should note that Rule 1 itself provides a useful tool for dealing with information. First of all, we should adhere to the rule rigorously when thinking of voids and inadequacies in the battery literature; that's a rule and not a logical deduction. I mean we should look for voids and inadequacies in the battery literature without regard to who wrote the literature or where the work was done. We should learn to recognize inadequacies in reported work without ever hinting at an inadequacy in the man who did the work. Again, this generality is easy to state but all of us have a weakness, to differing degrees, by which we tend to judge technical papers by who wrote them rather than by what was written. My first rule must be obeyed if we are going to get scientific about the work of science and the voids and inadequacies in its literature.

A second result from Rule 1 is that the scientist aspects are extremely useful for the storage, retrieval, or handling of information. Thus, we have Author and Facilities Indexes. Names of people and places provide one of the quickest ways to retrieve or to identify documents and other kinds of information.

Returning now to the work equation, I'll review its basis again, quickly, for those who were absent from last Thursday's meeting.

You may recall that I suggested the first step towards a scientific definition of science was to look for some dimensions. We need to measure science, and the first step toward being scientific is to select the dimensions to be measured. A later step will be to define the yardsticks and standards for comparison, but there is no need to define a yardstick unless we can first agree on a need to measure length.

The first dimension to be selected is one of Amount. If we are going to measure science, we need a measure of its amount. And I wish to define this amount dimension by analogy with the physical sciences:

**EXHIBIT 15. AMOUNT DIMENSIONS FOR SCIENCE  
AND FOR BUSINESS**

- 
- Amount of Electricity = coulombs, ampere-hours, etc.
  - Amount of Gas = volume, cm<sup>3</sup>, liters, etc.
  - Amount of Liquid = gallons, ft<sup>3</sup>, barrel, etc.
  - Amount of Surface = area, ft<sup>2</sup>, cm<sup>2</sup>, etc.
  - Amount of Mechanical Movement = distance, ft, cm, mile, etc.
  - Amount of Science = observations, facts, etc.
  - Amount of Business = supplies, products, etc.
- 

The more facts and observations we have, the greater will be the amount of science. Incidentally, I will carry along, at the same time, a proposed scientific definition of business for two reasons. First of all, research is a business to many people, and second, its units will help to illustrate the choice of dimensions.

Next, we need to select a dimension for the Intensity of Science. Again, by analogy with the physical sciences, we have:

**EXHIBIT 16. INTENSITY DIMENSIONS FOR SCIENCE  
AND FOR BUSINESS**

- 
- Intensity of electricity = potential, voltage, etc.
  - Intensity of gases = pressure, pounds per square inch, etc.
  - Intensity of liquids = height, cm, pressure, etc.
  - Intensity of surfaces = surface tension, dynes/cm, ergs/cm<sup>2</sup>, etc.
  - Intensity of mechanical movements = force, dynes, lbs, etc.
  - Intensity of science = predictions, ideas, theory, etc.
  - Intensity of business = customer satisfaction
- 

These amount and intensity dimensions for science and for business are proposed this particular way for several reasons. One reason is inherent in the need to remain consistent with experience. Thus, to retain consistency with the analogy from the physical sciences, we cannot pick out just any old dimensions. They must be selected (and here is our first test to see whether we've picked the correct dimensions), these dimensions must be selected so that when the Amount dimension is multiplied by the Intensity dimension, the mathematical product evokes in our minds a concept of work.

## EXHIBIT 17. WORK = INTENSITY X AMOUNT

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Work of electricity = volts x coulombs passed =  $E \times I t$   
 Work of gases = pressure x volume moved =  $P \times V$   
 Work of liquids = height x volume moved =  $h \times V$   
 Work of surfaces = surface tension x area changed =  $\gamma \times A$   
 Mechanical work = force x distance moved =  $F \times d$   
 Work of science = ideas x facts =  $I \times F$   
     = predictions x observations =  $P \times O$   
 Work of business = customer satisfaction x supplies =  $C \times S$

---

At this point of my presentation, we have entered into the vast technical areas of work and energy and all that those concepts involve. I find the opportunities for philosophy become unlimited from this point on. At the same time, as I foresee opportunities, I also observe a frequent occurrence of fuzzy thinking. Many people don't know the difference between work and energy, or between work and power. They are unfamiliar with the dimensions of work and about what happens when the work of liquids is converted into mechanical work which, in turn, is converted into electrical work that is used to provide chemicals upon which a scientist works. Without going into all those ramifications now, let me present some of the obvious consequences from the Work of Science equation.

The first point of note deals with the extreme conditions when either the intensity dimensions or the amount dimensions are zero. Thus, zero ideas x any number of facts is always equal to zero scientific work. When this extreme condition exists, we are "data gatherers", or "accountants". In the same way, any amount of ideas or predictions when multiplied by zero facts or observations leads to zero scientific work. In this instance we are "dreamers" or we are "guessing", or perhaps "we are writing science fiction".

Another point of note derives from the accepted definition of power, which is the rate at which work is done:

## EXHIBIT 18. THE WORK AND POWER OF SCIENCE

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Work of Science = Ideas x Facts  
     =  $I \times F$   
     =  $W_s$   
 Power of Science =  $dW_s/dt$  = rate at which work is done  
     =  $[I \cdot dF/dt] + [F \times dI/dt]$   
               ↑                          ↑  
              Observation                  Prediction

---

I've boxed off the two parts of the power equation and labeled them because these are the two boxes in which day-to-day science is done. These boxes are where you find a scientist and, interestingly enough, we find with experience that it is impossible for a scientist to be in both boxes simultaneously. That is, we can observe and we can theorize and we can do either one first. But it is impossible to do both at exactly the same time, just as an artist must first conceive of the picture before he

can paint it or, alternatively, he must first start painting before he imagines what the picture is going to be.

As partial evidence that scientists tend to specialize either as Observers or as Predictors, let me show you a few quotations I've picked up from some famous men:

EXHIBIT 19. PARTIAL EVIDENCE THAT SCIENTISTS TEND TO BE

<u>Observers</u>	<u>or</u>	<u>Predictors</u>
1. "Sit down before fact like a child, be prepared to give up every preconceived notion, following humbly wherever nature leads, or you will learn nothing".	T. Huxley	1. "The secret workings of nature do not reveal themselves to one who simply contemplates the natural flow of events. It is when man interferes with nature, tries to make her do what he wants, not what she wants, that he begins to understand how she works and may learn to control her".
2. "I must begin with a good body of facts, and not from principle in which I always suspect some fallacy."	C. R. Darwin	2. "There is no logical way to the discovery of these elemental laws. There is only the way of intuition which is helped by a feeling for the order lying behind the appearance".
3. "Now, of course, there is no question that one of the necessary conditions for scientific investigation is an exact and impartial analysis of the facts."	J. B. Conant	3. "With accurate experiment and observation to work upon, imagination becomes the architect of physical theory".
		J. Tyrell

I have a few more famous quotations and, incidentally, if you run across such famous quotes I'd appreciate your calling the reference to my attention. The point I wish you to note at this time is how these prominent scientists appear to contradict one another. Thus,

Thomas Huxley says, "Sit down before fact like a child...", whereas

Francis Bacon says, "The secret workings of nature do not reveal themselves to one who simply contemplates...".

Charles Darwin says, "I must begin with a good body of facts...", whereas

Albert Einstein says, "...There is only the way of intuition...".

Darwin says, "... I always suspect some fallacy from principles", whereas Einstein says, "(one) is helped by a feeling for the order lying behind the appearance".

James B. Conant says, "one of the necessary conditions is an exact and impartial analysis of the facts", whereas

J. Tyndall says, "Imagination becomes the architect...".

Referring back now to the slide on The Work and Power of Science (Exhibit 18), the points I wished to stress with the quotations were:

- (1) Both Observation and Prediction are necessary
- (2) No one can Observe and Predict simultaneously, and
- (3) Each one of us who is to do the work on this project must recognize when he is observing or when he is predicting.

This last point about recognizing the box we are in is made because,

If you are going to observe, you must start with an idea. Otherwise the result will be a collection of unscientific numbers or random facts.

If, on the other hand, you are going to be a predictor or a theorist, or an idea man, you must start with some known facts. Otherwise, the result will be a collection of wild guesses saying, "We tried this or we tried that, but nothing seemed to work out".

I hope we can follow the direction of thought implied in the "power boxes" as we review the literature for voids and inadequacies.

Before proceeding to relate these equations (Exhibit 18) to information problems, I must tell you that work can be described another way. To do so, we will need an additional dimension for measurements where the work has gone. For the First Law of Thermodynamics tells us that energy, or work, is neither created nor destroyed. Work has to come from someplace and has to go someplace. There is no magic and no perpetual motion. Again, we may have a semantics problem, but I have come to favor the word Distribution for this third dimension. The word distribution suggests that work is spread about and, as before, we can illustrate distribution by analogy with the Physical Sciences:

**EXHIBIT 20. DISTRIBUTION DIMENSIONS FOR SCIENCE AND FOR BUSINESS**

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Electrical work is distributed over  
the impedance of a conductor, or  
over the area of a capacitor, or  
through the inductance in a transformer, etc.

The work of gases is distributed  
as mechanical motion, or  
as heat, or  
as a change of temperature, etc.

Mechanical work is distributed  
as kinetic energy, or  
as heat, or  
as entropy, etc.

The Work of Science is distributed  
through the uses of science, or  
by applications, or  
by publications, etc.

The Work of Business is distributed  
with dollars, \$

---

The distribution dimensions in the physical sciences become somewhat complicated to describe because they are mathematically related to work in different ways depending uniquely on the given scientific situation. Thus, the equations for electrical impedance depend on the circuit and when the equations are deduced they may bear no relationship to the equation needed for mechanical work or for the work of gases. We have learned to cope with these complex relationships in the physical sciences by providing units of measure. We have simplified the physical measurements but find the interrelationships of physical work with its physical distribution is complicated. In contrast with the physical sciences, the distribution of any human work is easily related but, perhaps, difficult to measure. The distribution of work that is done by people is easily stated and related because there is one, and only one, relationship between human work and its distribution. I call this relationship the Work Law, and it's true because no one has ever proven it to be false:

**EXHIBIT 21. WORK LAW AND THEOREMS**

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The Work Law:

$$\begin{aligned} \text{Work} &= \text{Amount} \times \text{Intensity} = \text{Growth of Its Distribution} \\ &= Am \times Int = \pm d D/dt \end{aligned}$$

A Theorem of Science:

$$\begin{aligned} \rightarrow W_s &= I \times F = \pm d(\text{Uses})/dt \\ P_s &= [I \times dF/dt] + [F \times dI/dt] = d^2(U)/dt^2 \end{aligned}$$

A Theorem of Business:

$$\begin{aligned} \rightarrow W_B &= C \times S = \pm d(\$)/dt \\ P_B &= C \times dS/dt + S \times dC/dt = d^2\$ / dt^2 \end{aligned}$$


---

In this projectural, we have a  $\pm$  sign because changes can be either an increase, positive growth, or a decrease, which would be called negative growth. For the Theorems of Science and of Business I've inserted the previously described dimensions of Prediction or Ideas (I), Observation or Facts (F), and Uses for Science (U), as well as Customer Satisfaction (C), Supplies (S), and Dollars (\$) for Business. Thus, a dimension for the work of a business becomes \$/hour, which I find exceedingly easy to measure. (I call the first relationship a law and the last two relationships theorems, because the law is an absolute that is true whether we like it or not, whereas the theorems depend on our choice of words. All three of the equations satisfy the six criteria that can be associated with Scientific or Physical Laws, but this digression is another subject.)

The work law and its accompanying theorems are brought into this presentation because, as I've pointed out, we operate dimensionally and conceptually in power boxes. Therefore, the power of science becomes equal to the first time derivative of work; power also becomes equal to the second time derivative of distribution.

Thus the work of a businessman may be measured by \$/month, but the power of a businessman is to be measured by the way he changes, or is capable of changing, the work. Show me a business which brings in \$1 million/year this year, \$2 million/year next year, \$4 million/year the following year, and I will show you a powerful business.

In a like manner, if we know how scientific work is to be used, or distributed, then our scientific power can be measured directly by the acceleration rate of its applications. On the other hand, if you will show me any scientist who does not know how his work is to be used after he completes it, I will predict right now, before the result, where that scientist will end, to wit:

"It's a very complicated subject", he will say. "It's surprising how little we really know."

Such a statement is probably true, but I believe we've gotten past that musical chair by recognizing the dimensions necessary for the scientific work of this project.

Referring now to last Thursday's schedule:

At 10:50, Mrs. Johnson is going to touch briefly on battery literature. We have to know where the science is before we can talk about changing it.

From 11:00 to 12:00, and for a half hour after lunch, Linebrink, Thompson, Roeger, and Hardy are going to talk about getting the facts about batteries. The ways in which Mr. Roeger increasingly uses the techniques and results from other parts of the program will provide one measure of the power of our own work.

Someone once said to me about this theorem of science, "I don't know how to measure a prediction or an idea nor how to measure an observation or a fact, so how can I measure the product of two of them, or their rate of change with time? Those are pertinent questions, and the answers are equally pertinent because you just do it. We'll have to quit thinking about what can't be done and about whether we like it or don't like it. When we review the literature we should note (1) what observations

preceded the thinking? or (2) what thinking preceded the observations? and (3) how are the results to be used? Thus, there is no need for problems with words in the theorem of science. The equation can be absolutely true, whether we like it or not, just as I could care less whether you measure distance with ft, cm, miles, yards, microns, Angstroms, or mm, nor whether you measure the amount of science with facts, observations, data, or any other unit of measure you choose.

Let me show you an interesting numerical example. Suppose we restate the power equation using the word facts,  $F$ , for the amount of science and the word idea,  $I$ , for the intensity of science:

$$P_s = [I \times dF/dt] + [F \times dI/dt] = d^2(U)/dt^2$$

We've ended up with an equation that facts  $\times$  change of ideas with time + ideas  $\times$  way facts change with time is equal to the power of science. I want to take two numerical cases. Case 1, we have 100 ideas and 100 facts, whatever they are, there is 100 of each, and by judgments that you might apply, we increased each by one; we added the observations up to 101 and increased the ideas up to 101. Then, this comes to be numerically

$$100 \times \frac{101 - 100}{1} + 100 \times \frac{101 - 100}{1} = 200 = P_1$$

In the second case, we start out with just one idea and one fact and we increased our fact by 1 and our idea by 1. Then

$$1 \times \frac{2 - 1}{1} + 1 \times \frac{2 - 1}{1} = 2 = P_2$$

so that in this hypothetical case I've given you, power in the first equation is 100 times as much as it is in the other case because we start out with 100 times as many ideas and 100 times as many observations. Now, in this particular example, I took this factual box equal to this predictive box, and you have to satisfy that condition mathematically so

$$F \times \frac{dI}{dt} = I \times \frac{dF}{dt}$$

Time cancels out, and we have the fractional change

$$\frac{dI}{I} = \frac{dF}{F}$$

If we look up these differential equations in a handbook, they integrate to the logarithm of the ratios:  $\ln \frac{I}{I_o} = \ln \frac{F}{F_o}$ . So if the logarithms are equal, the ratio of the ideas and facts is equal:  $\frac{I}{I_o} = \frac{F}{F_o}$ . If I rearrange the latter equation, we have

$I = I_o \frac{F}{F_o}$  and  $F = F_o \frac{I}{I_o}$ , which when substituted into the starting equation

$$W = F \times I$$

ends with

$$\frac{W}{W_o} = \frac{F}{F_o} \times \frac{I}{I_o},$$

so that in the examples we have taken, we have

$$\left( \frac{W}{W_0} \right)_1 = \frac{101 \times 101}{100 \times 100} = 1.02$$

and in the other case,

$$\left( \frac{W}{W_0} \right)_2 = \frac{2 \times 2}{1 \times 1} = 4.00$$

So, in this numerical exercise, we had the first case where there were many ideas and many facts; we added one more and our work ratio went up 2%. But in the second case, we had very few facts and ideas and when we added one more of each, our work went up 400%. I think this is pertinent to what we're talking about with batteries. We've got the old art that goes back to ancient electrochemistry: Patents come up to over our ears in number, yet we have hardly touched at them on this project. Batteries are a big scientific subject where many facts and many ideas exist. Remember now, we're starting a new project in which people will look at it and say, what did you accomplish? You know, we got a new idea and we got a new fact and we only changed the work 2%. It's an interesting relationship; I thought so anyhow. Inherent in what I just discussed is the reason why you can get this kind of research and why, at the same time, if you try to open up a new field where there's practically nothing known, your idea is strange because people haven't heard that kind of thing; you can't get support. You've got no power at all. It's the guy that gets in this large field ( $P_1$ ) that's got all the power. It's the guy that goes in this small field ( $P_2$ ) that will make the outstanding progress when he makes his work grow.

Marsh I've one question. How can you treat facts and ideas as independent variables?

McCallum Well, I'd say, to me, that's the same question as how can you treat volts and coulombs or volts and amperes as separate entities? You can't have one without the other. It's impossible to have a volt without some electrons around it.

Marsh Are they independent variables?

McCallum They're independent in the sense that you can have the same work accomplished with a few ideas and many facts as with a few facts and many ideas. But without either one fact or one idea we have zero scientific work.

Marsh Well, the way you differentiate these, they have to be independent variables, am I correct?

McCallum Right. Why shouldn't they be?

Marsh Well, I'm asking why should they be? In other words, you have to have a fact; normally, ideas are based on some facts, though maybe not directly related. When someone says that Einstein developed the relativity theory out of thin air, his whole theory, well, several books on the history of physics point out that he really had some facts and observations which he based his theory on. It just didn't evolve out of a nightmare Einstein had one night. If you knew the process, the observations, and the history of how this evolved, then you would have a better understanding of the theory.

McCallum Right. I agree with you. This is what the equation is saying. If Einstein wants to come up with some new ideas, he has to have some facts to start with. So he starts with some facts, then he starts changing the ideas. By the same token, if we are to go into the lab and make some observations, we ought to have an idea and go in and start changing or increasing the facts.

Moreover, some of us - I have a weakness like this myself - if I want to know whether a certain idea is good or not, such as another idea on batteries, the way I start sometimes deciding whether that's a good idea is to check the new idea against my present ideas. And so to evaluate an idea, I start with an idea. The result is unscientific thinking because it's not a question of whether your idea fits in with my ideas; the question is does your idea fit in with facts? Let's find out what the truth is about ideas not by checking ideas against ideas, but by checking ideas against facts or observations.

Now,  $W = F \times I = \frac{dU}{dt}$ . I see in this work equation four dimensions:

(1) observations or facts, (2) ideas or theory or prediction, (3) use - what's the purpose of this work, and (4) the time.

Coming now to our problem of indexing, dealing with 500 documents over there on the table, how do we know the state of the art? and how do we pick out these words? and how do we find the voids and inadequacies? This combination of problems, as well as all comments made today, can all be fit together with the theorem of science equation. If we're successful, every one of you will say, "That's great, that's just what I had in mind."

We can have some flexibility in words, but at the same time we're going to find that we have to discipline ourselves in word choices. We should not run around like a stroke of lightning wondering where to strike. We should start doing things, and yet there is just no end to the ways we can control our choices, so we can end up with an infinite number of controlled situations. Coming around to specific applications to these reports, take the manufacturing report or the report on silver migration. I'm suggesting to you that we go through these reports and that you make a note of what kind of facts and observations are in each report. Actually, since we operate here in the power box, what you eventually come around to, as I see it, is not what's likeable about it, but what's new, newly observed, or new theory.

Nevertheless, just to get started, I don't think we can worry about all observations, such as the first time a worker has observed the use of sausage casings for battery separators. What did he observe in this one report before you? Put some words down. We're going to have problems with words, but let's face them and let's start talking about what has been observed in that one report. A second thing is what about his ideas? And then the third thing is what are you supposed to do with the work

reported? What is the use of this material, and what's the application of it? We pick out our words with those three thoughts in mind.

Marsh Well, I think that since it is such a small group of people, if each person would put down what areas he's vitally interested in, such as instrumentation processes and so forth, and if everyone defined their area of interest in keywords of their own area, then no matter who goes through a report each one could pick out the topics concerning them. In other words, depending on who reviews the report and what their interests are, unless you have some guideline for evaluating it, each one is going to evaluate a document according to his own standards. At the same time, if a reader has more or less the standards of the other people and what they're interested in, maybe material pertaining to those interests could be indicated also.

McCallum This aspect of how to proceed is what I want to face up to because I think you're getting a personal aspect into our proceedings. What's this author interested in? I'm saying that I can pick up any one of these reports and I may or may not be interested in it personally and I may not know what you're interested in personally, but I ought to be able to tell what kind of observations have been made in this report. I ought to be able to say something about what ideas or what theories or what predictions or what abstractions are being used by the writers of the document. If I can't, I should recognize that my inability means I may not be expert enough to even read this report. For example, if I read about but don't know how to describe electrode kinetics, how could I even question whether those were good words or not? What do they mean? What's the idea behind them? I may think they're a poor combination of words, or the words might mean nothing to me. I think we always have problems with selecting words, and I'm offering to you a way to get around this problem of who it is that wants the information. Let's get personal interests out of it when we review these documents. Don't worry about who wants it and whether he likes your choice of indexing words. Let's just know what's in that report. Later, when you're looking for solubility data, or you're wondering about using sausage casings, or you're worried about compacting, or whatever word you've picked out, then you'll go back to the index, when that interest comes up, and say, "Now that we're on the subject of separators, I'll look at someone's choice of words and do my judging at that time."

Linebrink I think this brings up the point, though, that all of us are faced with a matter of time. We can't take time to digest the technologies of the areas other than our own. We don't have enough time to read everything, so we do have to say, more or less, "Well, this is somebody else's ball park," and toss that document on its way.

Marsh I wasn't necessarily speaking of analysis of a report or an interpretation of a report. For example, in many documents they're classified according to different tasks. We might be interested in only one task out of several tasks and what work is done in that part is most difficult for a reviewer to decide. He may not feel a responsibility to indicate what was actually there. If he had 100 reports, he couldn't possibly decide about another person's interest.

McCallum Your comment reminds me of what I think has been one of the greatest things that has ever happened in contract research, and it has to do with these milestones that the Air Force requires. I don't know whether people like milestones or whether

they don't, but I look at them as being an application of Rule 1: how do we separate opinion from fact and how do we leave the scientist out of the science? I find that milestones, the way I interpret them, and I'd appreciate your comments if I'm interpreting them wrongly, ought to be worded in such a way that they're not a matter of personal opinion. For example, we don't say "useful relationship devised" because whether it's useful or not depends on who you are and what you're trying to do, so it's a matter of opinion on whether it's useful or not. That kind of wording shouldn't show up on a milestone. On the other hand, you could say "relationship reported". Then, you may or may not like the relationship, but if I were to drop dead tomorrow, you could say, "Well, just before he died, he reported a relationship." The words have nothing to do with opinion anymore, you see; he did or he didn't, and that's the kind of milestones we ought to have. This independence of persons is what I'm talking about when I ask what's been observed in this report. It has nothing to do with evaluating it in the sense of it's good or you find it interesting. Let's just find out what was studied; what was observed?

I was leading back to the problem mentioned about enough time. You also can run into a problem with words and a problem knowing what an author observed. I'd say that some of these problems are not our fault because fuzzy writing does exist. As I mentioned earlier, many times it's hard to tell what a worker did observe. He may report polarization that could have been measured 10 different ways; so you don't know what he observed at all. But, if we all have a problem with words, we are going to recognize that problem when you say I don't know what this writer did observe. Conversely, you will tell what he observed, and you'll start assigning words to his reported observations. In that way, we're leading towards a thesaurus and we're leading towards words that can be handled 2 ways: either you pick out the words yourself, keeping in mind your friend who's interested in the reported subject matter or, alternatively, we have an information specialist on the job who we are training in the words to describe these various kinds of observations and ideas. She will catch on; any information specialist would catch on after a while, as to what kind of observations was made and what kind of theories an author is dealing with. By proceeding this way, we can get help from a third person. Eventually, a word choice will come to the point, take the word overvoltage, for example, where gradually I might realize that everything I read is about overvoltage. How are we going to decide whether there is a new idea there? Does this hypothetical document about overvoltage have any new ideas or does it describe new observations? Thus, I think the work equation provides a way to start controlling our access to battery information. Use of such a conceptual equation has to start with a small group like this if it's going to start at all. One shouldn't start with industry at large because they wouldn't know what you're talking about until the work was discussed with more detail. You've got to start with a group small enough to communicate the subtleties of working with old information in new ways. When we learn how to choose words, when we learn how to think in terms of these concepts, which I say provide rigorous relationships because there's no exceptions to them, then people will start to recognize a system that's working, that is useful, and they'll want to be part of it.

Hardy I'm not quite sure what it is you want us to do right now.

McCallum Two things. The first one is to take these documents that you've already been through briefly, go through them again in the light of what I've said, and see if you can pick out some words to describe 3 things: (1) the observations. (2) the ideas or theory, and (3) applications and uses.

Hardy Well then, what we're doing is backing up a few steps; we aren't going into voids and inadequacies at this point.

Marsh Well, we can point out voids and inadequacies.

Hardy From one report?

Marsh No. I assume you're going over more than one report.

Hardy Well, this is the thing that I was wondering. We have to go through a number of reports.

McCallum Right. But the first thing is the single reports handed out to each individual at this table. I'd like for us to review them a second time around: that is, you just went through them; let's do it a second time, on a separate sheet of paper. And let's see what's different. A second step then will be to go to work on the pile of documents behind us here on a separate table.

Hardy All right, let's say we go through the documents before us. We go through them and make a list of words in 3 categories: observations, ideas or theory, and applications. Then, how is it that we go about discovering voids or inadequacies? What criterion do we use next? I mean, we will have all of these different reviews and it seems to me that, unless our list of words is oriented in some way, we're just going to end up indexing these documents 3 different ways, which is fine. But this kind of reviewing doesn't help us define voids and inadequacies because, to me, and maybe this is where my difficulty lies, my understanding of voids and inadequacies requires that we think in terms of some application, of some utilization of the information. For example, are we going to build a battery? Are we going to draw up a handbook on solubilities of silver oxides, and another on the polarization curves for nickel-cadmium cells? One might say there are no voids or inadequacies, if we're going to draw up a handbook, but if we're going to use these reports in a certain way, then we need to know certain things. Thus, it seems to me a void or inadequacy implies a question that's in mind beforehand and this question is what I see is missing right now. Maybe if we had a list of 10 questions, or even some general idea in our minds of what we were going to be asking ourselves later, then when we write down these keywords, we can say, ah! here maybe is some information, some observations or theoretical discussion on exactly that question. On the other hand, perhaps this other document doesn't have any matter pertaining to the question in mind, although it has some other observations. Any document review has to be related to some question. We're trying to create a bunch of answers without having any questions, I think.

Linebrink You've got a very good void; what are the indicators of battery failure?

Miller I think that's what we're all geared to do, screen the literature to see what's missing in the battery technology that may cause batteries to fail prematurely. We'd like to describe the weaknesses so that we could concentrate our research on the most important needs. But you're right; you must ask yourself certain questions. Now, in Paul's case of setting up electrode fabrication and actually constructing electrodes, he must ask questions. What amounts of this do I use? What size electrodes? He will have even more definite questions he could ask.

Marsh Yes, dealing with techniques and equipment.

Hardy But his questions are different from my questions so that for him these reports may be full of voids and inadequacies. (General comments of agreement.)

Miller I imagine his answers would be very few. Most documents do not describe details of electrode fabrication.

Hardy When I'm looking for an empty spot, I sort of have to go over all the solid ground until I find a hole. I guess this is what my comments amount to.

McCallum I think there are at least 2 answers to your question about how do we tell where the voids and inadequacies are and this matter of prepared questions. One answer is that we received some written questions today, did we not? We haven't told you about those questions. A second point at our disposal is the observation and the predictor boxes. What observations are we picking up in these documents, what ideas? Then, after I get that information, I can start asking questions. I can start thinking about new ways to use the information after I get the facts and ideas from a document. This is another possibility. So I have 2 ways: one is I start out with a question and see if I can find the answer; the other is give me the facts and ideas and I'll start asking some questions about them.

Hardy Which way are you suggesting we use now? This one to give you the facts and ideas so you can start asking questions?

McCallum I think what I'm asking for now is let's get the information out of the one document. I'm having semantic problems with facts and information.

Hardy Yes, because the difficulty lies with semantics.

McCallum Let us talk first about indexing this one document. When we're through, we'll have some questions about what was in the document. Now, I had thought, before the meeting today, that questioning was something we can do after we get your keywords or comments. But now we have the other point that while we're looking through these documents, we should have prepared questions. I hope this isn't getting too complicated, but there are two things I'm asking for: that we go through these, first of all; perhaps there are 3 things -

Marsh I might make the comment here that we've probably picked the most difficult reports in the world to go through and evaluate: a government contract report. They are the most difficult to review because if you have a journal article, generally it's concerned with just one small subject area, whereas, with government reports we're not necessarily limited to one subject. Moreover, we don't aim to take all sponsored research to its conclusive end. We're trying to improve; any small improvement we can get over an existing system is a gain. So there're several different subjects involved in any one of these reports before us and they're not, in 99. 99% of the cases, complete.

Brooman Just observations or speculations.

McCallum Okay, but still for this later part of our experiment, if I just knew what's been observed in that report, what is in there that's factual information that might be used; just write it down. I could decide later whether I can use it or not and so could you decide later.

Marsh I'm not saying whether you can use it. I'm just saying that these documents before us are made up of so many different disciplines and degrees of factual information that it's more difficult for one man to sit down and decide what's in one of these research reports.

Linebrink You can't scan it and accomplish very much.

Marsh You can't scan it in the way you might scan a journal article.

Linebrink There are many, many facets of interest to many different people in most reports.

Miller I think John has pointed out the importance of evaluating a report in the proper light, i. e., in terms of observations or facts and predictions or ideas. However, I always must proceed with some questions in mind. I know of Eric's interest in thermal analysis, for example. Before he reviews the literature, he must have at least one question in mind - what's gone before me? I just reviewed the accession list. I think there were 13 different articles on thermal analysis. So starting with preconceived questions might be a handicap because quite often authors don't emphasize all parts of their work.

Brooman The document titles are so vague that I might not go to that paper anyway, such as a general one about thermal effects.

Miller There's hardly any specific information on thermal analysis. What I'm suggesting is that somehow we put ourselves into a frame of reference about what we want to look for by organizing a couple of lead-in questions. Then we can evaluate

the documents in terms of what was observed, what are the facts, what's the supporting theory, and its state of development? But I'm not sure if these particular reports can be handled that way.

McCallum I suggest you might do 2 things: (1) starting with an idea regarding thermal analysis, you might see what facts you find in this report about that idea. (2) At the same time, you might have certain facts in mind while you peruse this report for ideas that explain or help you to use your own data.

Marsh John Jones here is interested in something different from you.

McCallum Perhaps so. I don't know what John Jones is interested in. But what's the man who wrote the report reporting? When you give me that information, I can decide whether I want to use it.

Hardy But, John, we can dig out tons and tons of facts or ideas. I could probably write as much of a report, or twice that much, on just this one report in my hand. Facts - you know - they don't mean anything by themselves because they don't have any relation to a goal. I mean, we're going back right now to the question that you sometimes pose when we go into the laboratory when you say let's not just pot around and get some data or facts. These facts have to be obtained for some reason. I'm saying it again: that facts have to be obtained for some reason, and you can't do it within a vacuum. I think that within our own discipline of interest is the way we have to consider a document.

McCallum I'm not contradicting that. I'm only saying that in addition to your own interest, what about the authors? You're going into it with an idea of what you want and you'll find out if it's there, but what about the author's idea? What was it that the author had in mind?

Marsh But what's the reason for this literature search and survey? To identify voids and inadequacies? Shouldn't that be sufficient?

McCallum It's more than those. I wish that was all. I'm saying there is more than one thing to do, and they are never-ending tasks. One is to identify voids and inadequacies in the literature we read. The other thing we want is to keep abreast of work reported by others. What was the first question we asked today: how do you keep aware of developments? And this awareness is part of what should come out of our reviews. We've got to start. We have another 2-1/2 years together. We ought to start using this information more and more, not less and less, as time goes by.

Hardy I can't assimilate facts without having a question posed in my mind. Now maybe this is the thing to do: what question was the investigator trying to answer? Did he? And what facts are pertinent to that? Maybe this is the way to do that.

McCallum Excellent! Very good!

Miller I feel a way you organize this battery literature might serve for years to come. But we still have the problem at hand in trying to satisfy in the near future about what we will call the voids and inadequacies. This is why I suggested that maybe we do put ourselves in each discipline and review the first reports in light of what you were saying about the work of science. I think that's a very good idea, but we have to start somewhere and I also believe, in the interests of time, that our questions may soon lead to terms. Like Paul was saying, we should help the information specialist with a group of questions and then terms. The specialists, in turn, could help screen some documents and say, for example, that this report doesn't really go into detail on measurements, even though measurements were made.

McCallum Let's just go to work on the documents before us. First, I want you to review the documents you did once before in the light of this work concept; try and use it; it may fail, but try anyhow. The next step - you'll have 2 sheets on one document then - would be to work the document again with a list of questions. Are we ready to let people have them, Dottie? You can go about this second review any way you want to. I hope you'll find this work concept useful. You can ask the questions; you can have the ideas; you can identify the facts reported.

Johnson Would they like to have the sheets back with the questions that they asked?

McCallum No. Maybe we ought to have a tabulation of the questions. Is that possible to put together?

Hardy We could just read through them. I probably can't tabulate them. Just read through all the questions.

McCallum I don't want my questions back. I know what they were, but I don't know what these other persons asked.

(General conversation not picked up relating to  
an oral reading of the questions listed in Exhibit 22.)

Marsh Is there any way that someone could define or list the parameters of the battery?

Hardy I'll vote for you to do it.

Marsh I mean, you have separators, current-carrying substrates, active materials, electrolytes - one could list all these different components.

Hardy Right now you're mixing functional components and structural components.

EXHIBIT 22. QUESTIONS LISTED IN RESPONSE TO ITEM 3 IN EXHIBIT 2

---

1. How to make electrodes?
  2. How to define, detect, measure "failure"?
  3. What units of measure are most commonly used for batteries?
  4. What "failure mechanisms" are mentioned in the literature?
  5. What is the mechanism of  $\text{Ag(OH)}_2$  decomposition in alkaline solution?
  6. What are the failure mechanisms of Ni-Cd and Ag-Zn cells in spacecraft?
  7. What is an acceptable operational definition of cell "failure"?
  8. Reports in which measurement techniques on batteries are described in detail are scarce. May I see any and all reports which do have measurement techniques described?
  9. Show me specific definitions of the following terms:
    - (a) End of charge voltage?
    - (b) Open circuit voltage?
    - (c) Overcharge?
  10. Are there expressions, in equation forms, for describing battery performance and capabilities? Equations to identify standard units for comparisons among systems but on a normalized basis?
  11. Thermal properties of individual battery components, and materials presently used or likely to be used?
  12. Actual values for charge/discharge cycles of batteries in use, and times of discharge, etc.?
  13. Explicit descriptions of manufactured cells such as number and type of case, type of connections, etc.?
  14. Thermal properties of batteries or complete cells?
  15. How to measure the effectiveness of an information system including assigning values to selected measurements?
- 

Marsh All right, you list them then.

Hardy Well, you can do it, but I think you have to categorize components because you get an overlap otherwise. Suppose we list functional things, like a current-carrying structure, and you can list structural or actual physical arrangements.

A-63 and A-64

Marsh There's going to be overlap; there's no way to get around it.

Hardy But it helps to separate out there.

Marsh A current-carrying substrate where it contributes both physically and chemically to the system.

Hardy That's a very general term. Look at nickel grids. It may or it may not have both physical and chemical significance. I think it's helpful to say that a battery is comprised of functional components and physical components. Another reason to consider functions one way or another leads you to describe battery parts functionally first, then their embodiment.

Marsh That's just it - .

(Everybody's talking.)

Tape Off.

## APPENDIX II

### SUBJECT INDEX TO TRANSCRIPTION OF TAPE OF JOINT WORK SESSION ON LITERATURE PERTAINING TO "FAILURE MECHANISMS ON SEALED BATTERIES"

Brand names as index terms; A-10  
Computer, man-machine communication; A-15  
Defence Metals Information Center (DMIC), description; A-20  
Evaluation of documents; A-44, A-59  
Experts as sources of information; A-14, A-35  
Indexing, depth of; A-28  
Information acquisition, methods; A-12, A-13, A-37  
Information acquisition, searching procedures; A-14, A-15  
Information analysis center concept; A-20, A-21, A-22, A-23, A-24, A-25  
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Work Law; A-50

## APPENDIX III

### INFORMATION ANALYSIS CENTERS

#### Definitions of an Information Analysis Center

Information analysis centers existed long before their functions were rigorously defined and they were recognized as a distinct type of information service. The first known attempt at a formal definition appeared in 1962<sup>(1)</sup>, some 11 years after the first Battelle-operated center was established. As these organizations have earned their place in the total system for communicating scientific and technical information, their activities have come into better focus. The following working definition by Simpson illustrates Battelle's concept of an information analysis center:<sup>(2)</sup>

One or more scientists, engineers, and information specialists, committed, at least part time, to providing to a specialized audience, the technically intellectual service of evaluating, integrating, condensing, and analyzing available information or data in a specific area of science or technology, or pertaining to a specific mission. The center provides answers to technical questions and provides to its specialized audience authoritative and timely data arrays, analyses, monographs, or state-of-the-art reports.

This definition is similar to and is an extension of the concept originally presented in the Weinberg report on "Science, Government, and Information"<sup>(3)</sup> and the definition accepted by the U. S. Department of Defense.<sup>(4)</sup> The definition as presented by the Department of Defense reads as follows:

Any functional element is performing as an information analysis center if it collects, reviews, digests, analyzes, appraises, summarizes, and provides advisory and other user services concerning the available scientific and technical information and data in a well-defined, specialized field. A center exclusively concerned with review and analysis of scientific or engineering data shall be considered an information analysis center. Such centers are distinguished from documentation centers and libraries, whose functions are primarily concerned with the handling of documents rather than the technical information contained in the documents.

#### The Information Analysis Center Concept

An information analysis center consists of three major operational elements: (1) an information and/or data acquisitions program, (2) a means for storing and selectively retrieving information and/or data, and finally (3) the response mechanism which produces technical responses to inquiries, technical compilations, and analyses. These functions are shown in Figure A-1. While this concept has been discussed in several papers by Simpson<sup>(2)</sup>, it is desirable to review it in some depth, because it is basic to Battelle's information analysis philosophy.

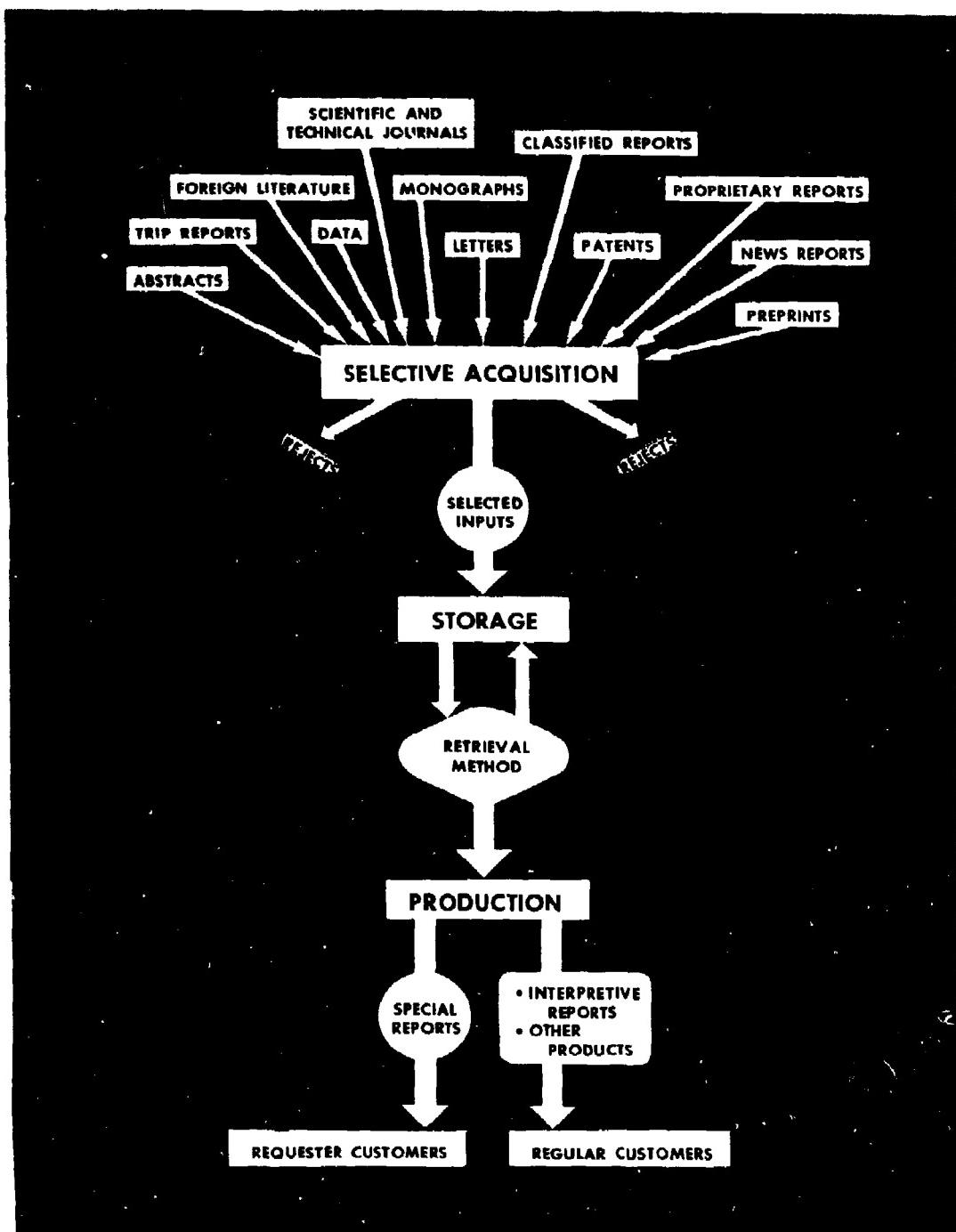


FIGURE A-1. THE PRIMARY FUNCTIONS OF SCIENTIFIC INFORMATION CENTERS

### The Acquisition Function

The top third of the chart represents the acquisition function - scientific information centers must identify and obtain the current data and information needed by their customers. If this is not achieved, the remainder of the center's efforts are jeopardized. To be able to identify what is important in the total information available requires trained information specialists plus the cooperative assistance of scientists and engineers. Maximum advantage must be taken of the technical staff in identifying the sources of information most important to the center. Further, the best means for insuring high-quality input is to give the technical staff the opportunity to review all material before it is accepted. Qualitative considerations<sup>(5)</sup> are vitally important to the center's program for collecting information and data. The acceptance of material that is non-relevant to the center's mission, that is duplicated, or is outdated entails unnecessary expense not only in the original processing costs, but also in recurring costs each time it is retrieved, considered, and rejected.

### Information Storage and Retrieval Function

The middle section of Figure A-1 represents the storage and retrieval functions of this center. It has been Battelle's experience and observation that the method which an information analysis center employs to store and retrieve information can be grossly overemphasized. The matter of system selection should be approached as a problem in resource allocation: to minimize expenditures for system operation and maintenance and to maximize expenditures on output. This is, of course, an oversimplification of a complex problem that will be treated more fully in a later section of this report, insofar as it affects EIAC. In general, however, it is a rare instance when a center is not to some degree fund-limited. It is basic to Battelle's philosophy of center operation that "trade-offs" should, in general, be resolved in favor of output functions.

### The Analytical/Production Function

The final portion of the chart is the most important and, as described by Simpson<sup>(2)</sup>, concerns money. Money comes from a sponsor or from a buyer of the services provided by an analysis center. The service provided by an analytical center ultimately takes the form of a report (in a broad sense), oral or written. Whether the sponsor is satisfied by the service depends not only on the thoroughness and economy of the center's operation, but also on his acceptance of the products of the center. The center's administrative staff must maintain an awareness of the proper preparation of its products, the most important characteristics being authoritativeness and timeliness.

Any center's greatest challenge is that of remaining responsive to the changing requirements of its patterns; requirements that change because modern technology is changing rapidly. The technical staff associated with the center is obviously in the best position to insure that the center adequately anticipate and adjust to the needs of its users. They must be in a position to make the necessary judgments and have the opportunity to express these judgments to the center's management.

There are three mechanisms by which Battelle-operated centers keep their technical staffs equipped to perform this vital task of orienting the center toward the user's needs: first, through day-to-day contact with the user in the course of answering his

inquiries; second, by encouraging the staff to attend and participate in important technical meetings and working groups; third, by constantly exposing the staff to the latest published, and often unpublished, information in their fields as it is acquired by the center.

The technical staff must be encouraged to express their judgments regarding trends in their fields of specialization. An effective means for soliciting these judgments at Battelle has been to formally request the identification of candidate subjects for report tasks. Consultation with the technical staff establishes an order of priorities for the tasks to be supported, and identifies for center management those areas where its services will be most needed.

#### Relationship of the IAC to the User Audience

Figure A-2 is a schematic representation of an information analysis center and its relationship to the user audience.<sup>(6)</sup> This diagram is consistent with and develops an operational concept of the accepted definition of an information analysis center. It is important that the concepts presented in this diagram be thoroughly understood by both the technical staff and the information specialists. In explaining the relationship of the user audience to the IAC, it is desirable to use a scenario approach.

To the left is a user audience, which may be either discipline-oriented (i.e., chemistry, metallurgy, forestry, or mining), or mission-oriented (forest exploitation, ballistic missile, pollution reduction, defense, or rural development). The user audience may be either widespread geographically and diffuse in their individual interests or centrally located (i.e., within a given organization). It is important that the user audience be defined and understood in depth, since the center's products must be developed to meet their needs. The users' direct and indirect expression of these needs provides the necessary guidance for the design of the center's products.

Within the context of the information analysis centers located at Battelle, the Remote Area Conflict Information Center is mission oriented, highly diffuse in scope, and serves a very select audience that is widely separated geographically. On the other hand, the Defense Metals Information Center is more discipline oriented (metallurgy), more limited in scope (certain high-temperature metallic materials used in defense systems), and serves a relatively broad American audience.

Within the user audience, the dot represents a specific user who is faced with a problem. The solution to his problem may or may not be in the literature. He may have exhausted his local sources, i.e., fellow experts, local libraries, etc. At this point he may decide to contact an IAC. If this is his first dealing with an IAC, he may state his request in terms of documentation:

- "Please send me all the literature you have on . . ."
- "Please send me a bibliography on . . ."

The IAC Project Director will have established a corps of experts (the Technical Specialist Interface) which (viewed collectively) matches the interests of the defined user audience. Within the Battelle context, the technical specialists are "lab-bench" scientists and technologists who are available part-time (as required) to assist the center. Their task is that of interpreting the user's needs, analyzing pertinent information and

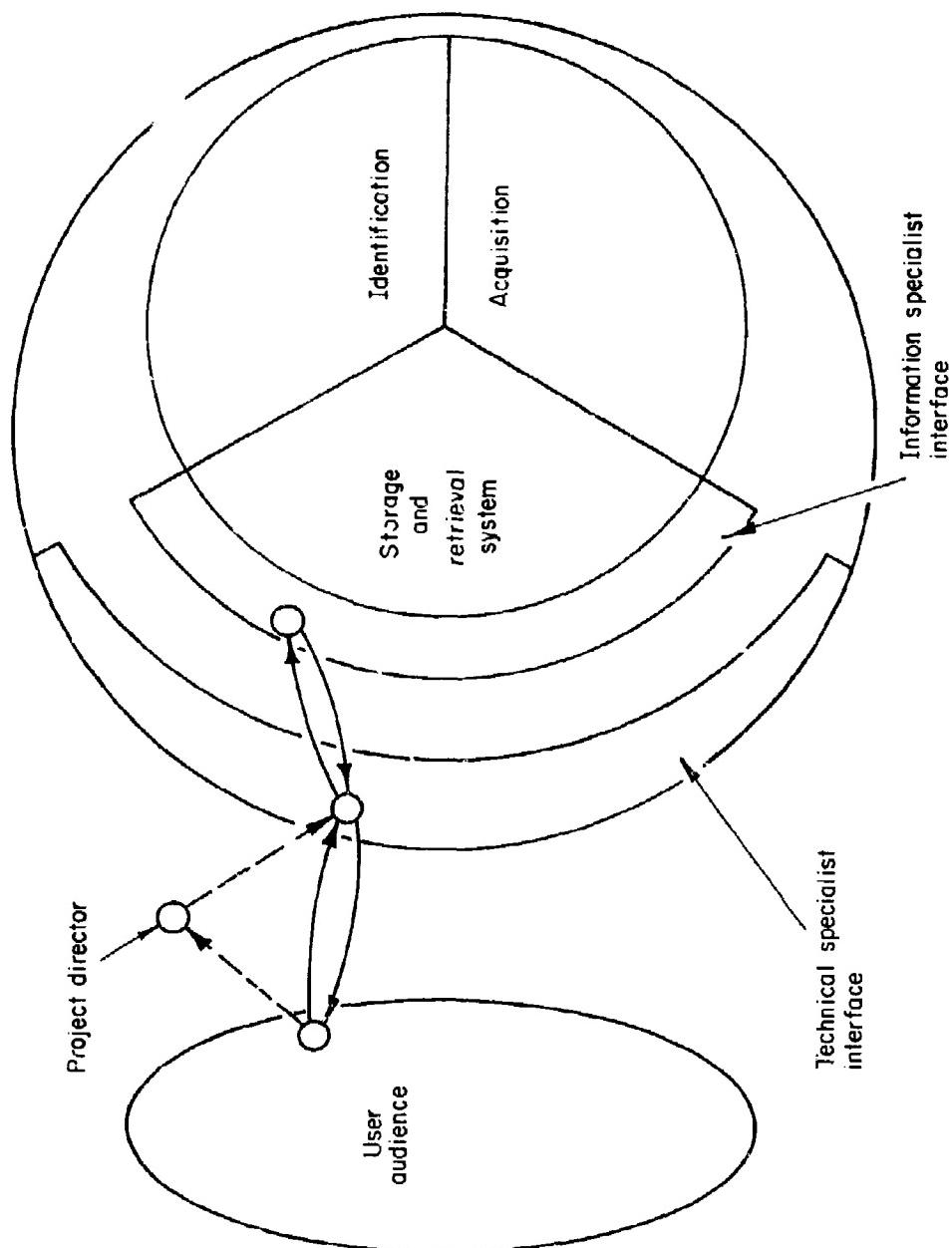


FIGURE A-2. THE LAC-USER AUDIENCE RELATIONSHIP

data, developing a reply, and communicating the reply to the user in terms that he can best understand.

The Project Director will select the best-qualified expert to respond to the user inquiry (as indicated by the broken arrows). Often, the expert will immediately contact the user-inquirer to obtain clarification of the original inquiry. Since the communication at this point is between fellow specialists (the solid arrows), the discussion will become technical in nature, and a technological rapport will develop. No longer is the communication (inquiry) in documentation terms, as above, but rather in explicit technical language.

Frequently, the technical expert will have a ready answer. He may be able to refer the problem to a fellow expert within the technical-specialist interface; perhaps he will suggest a knowledgeable source within the user audience; or he may have to refer to the information backup within the center to develop a solution to the stated problem.

In most IAC's the information backup takes the form of a specialized collection distilled from the general literature and indexed in the language of the center's mission, rather than in the stylized terms of the traditional index.

This deeply indexed body of information and/or data, the storage and retrieval system, is shown to the right in Figure A-2. Care must be exercised to select an information storage and retrieval system which will match the specific use patterns and requirements of both the user audience and the technical interface. System costs, both for establishment and for operations, would not be greater than the recognizable benefits of the system.

Since the members of the technical interface are primarily concerned with their areas of technical endeavor, they require a backup to operate the information system. The Information Specialist Interface at Battelle consists of knowledgeable scientists and technologists who have chosen not to be "lab-bench" scientists. This staff is oriented toward science information (i.e., chemistry, ecology, electronics, etc.) and toward the information science field (i.e., information-system design, communication theory, etc.).

Playing a dual role, this staff is able to communicate with the technical interface and to understand their information and data requirements in terms of both the center's system and other resources which might be useful (libraries, documentation centers, other IAC's, etc.).

Completing the concept is the all-important area of identification and acquisition of useful information which was discussed at length in the preceding section of this report (page A-3).

#### Information Analysis Center Versus Documentation Center

An important point to be gained from Figure A-2 is the differentiation between an information analysis center and a documentation center\*. If there is no technical

\*Documentation Center: an organization that performs all of the functions of a document center, i.e., selecting, acquiring, storing, and retrieving specific documents, and, in addition, announces, abstracts, extracts, indexes, and disseminates documents in response to requests (for secondary distribution) expressed as accession numbers, subjects, titles, authors, sponsoring agencies, or contract or grant numbers, etc. The output of a documentation center consists of the documents received, or copies of them, indexes, bibliographies, catalog cards, announcement bulletins, and the like.<sup>(7)</sup>

interface between the user and the information system, including the information specialists, then there is no true analysis center.

Under these circumstances, the user approaches other information specialists or librarians directly. The conversation between the inquirer and the information specialist usually resolves into discussions of literature searches, bibliographies, requests for specific pieces of information, or references. Only under rare circumstances will the conversation be directed toward the specific technical problem which is behind the inquirer's need for information.

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## APPENDIX IV

### AUTOMATION OF A BATTERY INFORMATION INDEX ACTIVITY

by

W. D. Penniman

The following discussion of automation procedures as they apply to the Battery Index Activity is divided into short- and long-range sections. The first section presents procedures that are capable of being implemented within a few months at moderate cost. The second section is much more extensive in scope and is presented primarily for purposes of discussion.

#### Procedures for Initial Automation

The tasks performed in production of the Battery Information Index have been evaluated for possible automation. Demonstration programming has been completed to prepare a computer-printed subject index from paper tape input.

The program originally developed has proven quite flexible and can be used as a foundation for any future programming that might be required to manipulate paper tape. This program, BATX, uses as a subroutine the paper tape read program PTP8C which is a standard library routine of the Battelle Computation Center.

The program BATX will accept any 8-channel Friden paper tape as input which has a format similar to that of your subject index. Specifically, the format should include:

- (1) Tabs or blanks for all line indentations (there should be no more than three tabs per line)
- (2) Line lengths less than 80 characters
- (3) Carriage return indicating the end of each line.

Minor modifications can also be made to the program to meet specific format requirements within certain limitations of tape/program compatibility.

The test computer program, BATX, represents an initial step toward a fully integrated system of automated procedures for preparing all required indexes and records in the Battery Information Index Activity.

The proposed automated system is presented in Figure A-3. The procedures for establishing such a system are presented in the following paragraphs.

#### Document Log-in

A work sheet is prepared in duplicate containing bibliographic information on each document. The original remains attached to the document during processing and is later

filed by accession number. The carbon is filed by first author as an interim record. The document is stamped with the identifying B-Number.

#### Assign Tentative Subject Terms

Information specialist reviews document and assigns tentative key words. These terms are entered on the work sheet attached to the document.

#### Abstract or Extract Preparation

The document is next reviewed for preparation of abstract or extract. If abstract is prepared, it is written directly on the work sheet. If the document is extracted, the pertinent document pages are noted on the work sheet attached to the document.

#### Unit Record Preparation (Accession List)

The information contained on the work sheet (bibliographic, abstract or extract, key words, and accession number) constitutes a unit record for each document. This unit record can be entered and stored on paper tape at the time the Accessions List is prepared since the same information is involved in both cases. The key words identifying each document are tentative at this stage, but may be entered on the tape for later revision.

#### Suggested This-Month-at-a-Glance (TMAG)

This list, consisting of accession numbers, facilities, type of report, and year of publication followed by a listing of suggested subject terms can be prepared directly from the information contained in the unit record on paper tape. A computer program can be written to extract the pertinent information and print the TMAG in the required format.

#### Corrections and/or Additions to Selected Subject Key Words

This list is prepared from the original unit record except for the key words which are from the revisions submitted by the technical specialists. At the time that this list is prepared the unit record stored on paper tape for each document is revised to contain the approval key words.

#### Indexes

Once the subject key words have been approved by the technical specialist and the unit records are revised on paper tape, final index preparation may begin. The unit record tape for each quarter contains all the necessary information for preparation of the required indexes (subject, author, facility, contract number, patent number, AD number, and N number). Quarterly tapes may be merged to produce cumulative indexes

when required. In addition to hardcopy computer output the information may be stored on magnetic tape for archival purposes.

#### Further Recommendations

The suggested "unit record" approach provides in machine-readable form all of the information required to generate the various products used in the Battery Information Activity. This procedure eliminates retying of old information, but still allows for revisions of key words, etc., on the paper tape. Because computer printed text has no lower case, super- or subscript characters, it lacks the flexibility of typewritten copy. Therefore, it is recommended that the format and rules of preparation for all indexes be carefully considered for user satisfaction. The computer programs for index generation should be written with a flexible output phase allowing for a wide variation in formats. In this way, formats may be readily revised as required by the users.

#### Projected Computer Utilization

This discussion of projected computer utilization contains some of the parameters of an optimum system. The description is intended primarily to provide a basis for discussion of the future needs of users in the Battery Index Activity. The previous section presented procedures and information techniques readily attainable within a limited time frame and with moderate funding. It should be recognized that the system described in the following paragraphs is much broader in nature and would require considerable time and funding to implement.

The system depicted in Figure A-4 consists of a series of remote consoles operating in an online mode with a central data file and computer. This type of system would place at the user's fingertips not only the information on batteries in the central file, but also the power of the computer for data manipulation. It would also provide the user with indirect contact with other users in the information network. Their input of battery information, once in the central file, could be available to all users.

#### Information Retrieval Network

The primary purpose of the system shown in Figure A-4 is to place the user in an information retrieval network and provide that user with a direct link with the computer and the information file. The user should be able to request and retrieve information on demand, and should have the means to provide information input to a central file for use by others in the network.

A primary requirement of generating an information file in machine readable form would have been accomplished during the initial automation phase depicted in Figure A-3. Time-sharing software and large-capacity random-access storage systems are to be incorporated into the Battelle computer facility within the next year thus making this projected system feasible for location at Battelle-Columbus.

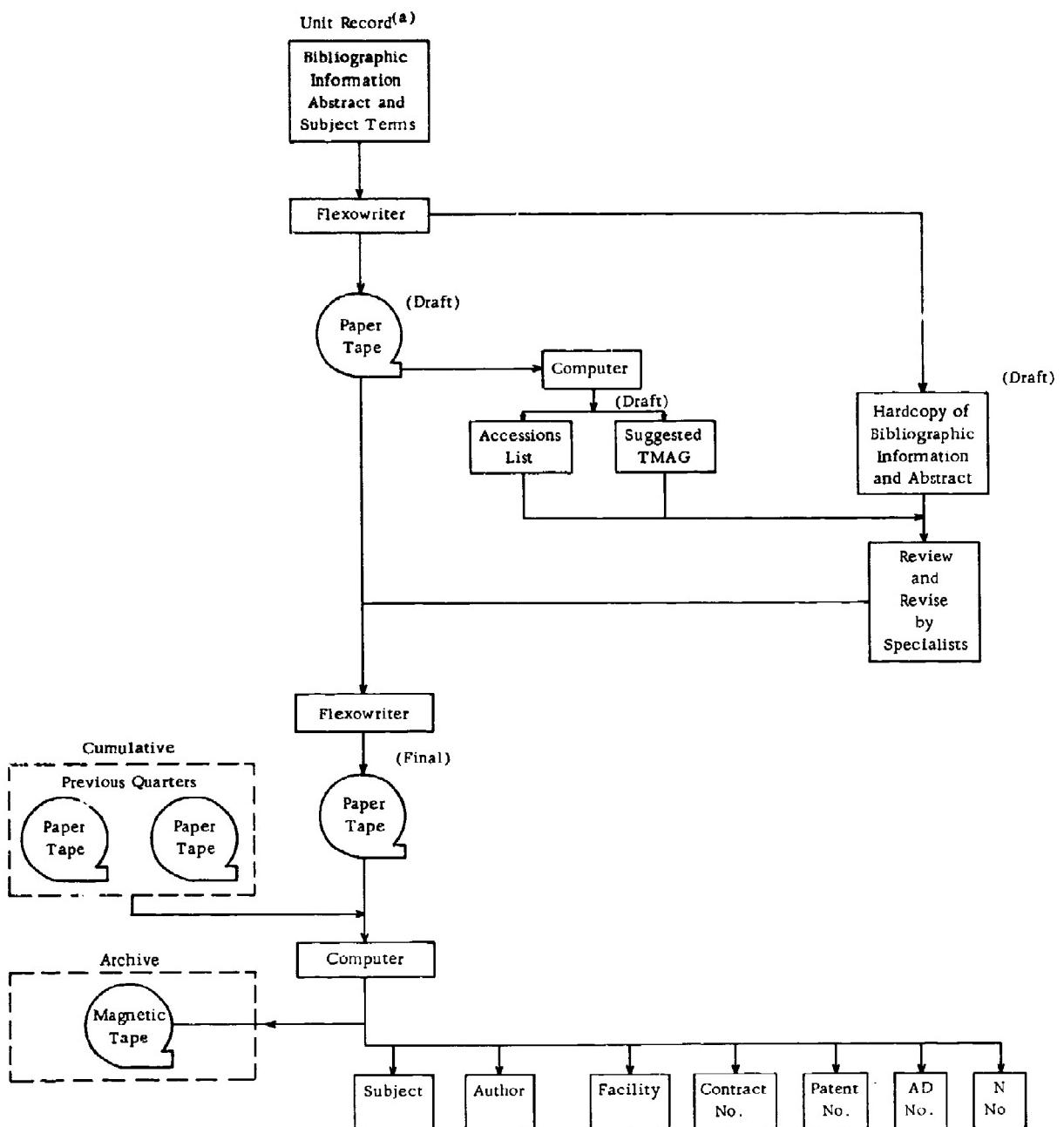
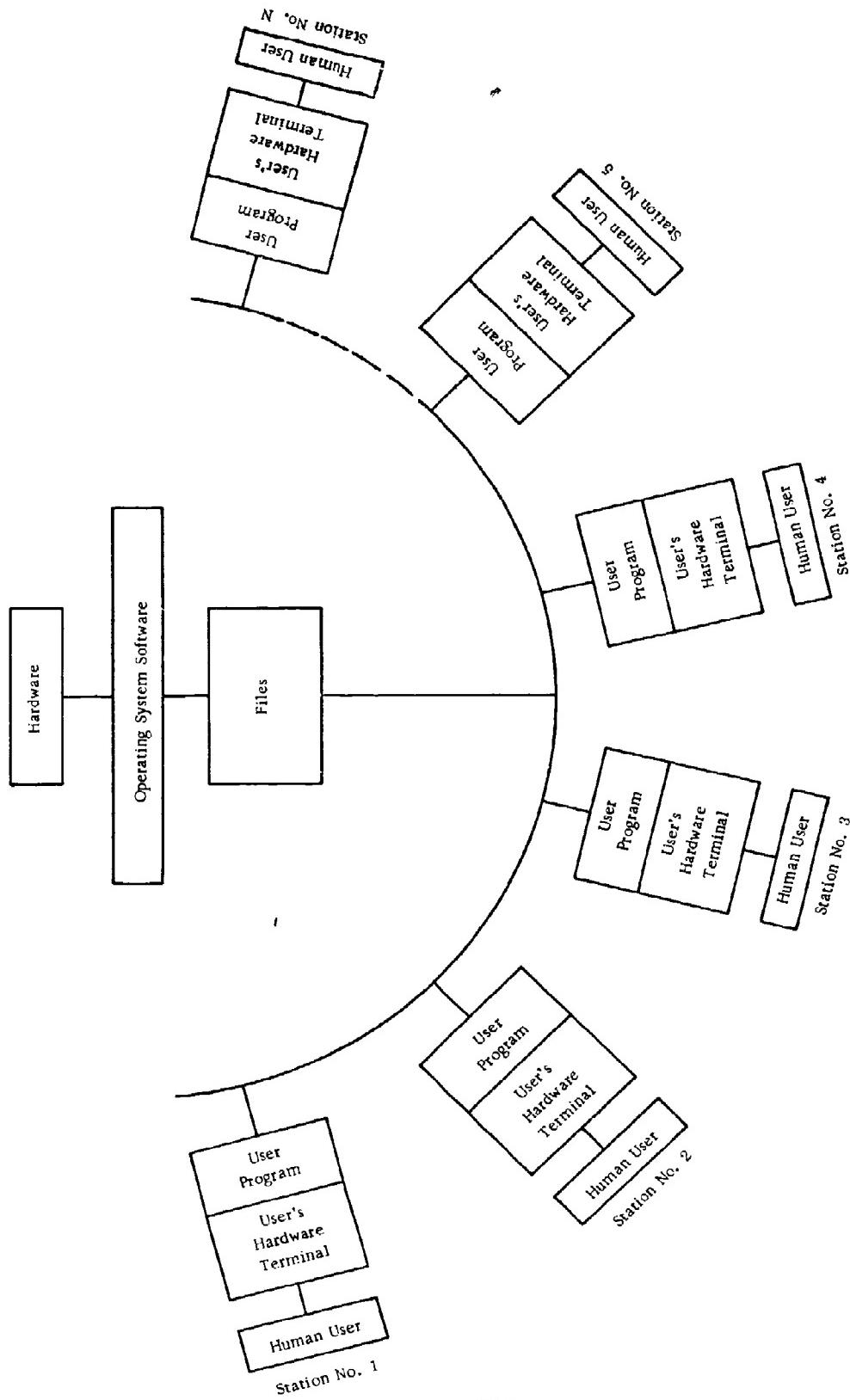


FIGURE A-3. SUGGESTED BATTERY INDEX AUTOMATION PROCEDURE

(a) Unit record is equivalent to single entry on the accession list.

FIGURE A-4. INFORMATION NETWORK BY MEANS OF REMOTE CONSOLES



### Engineering Design Tool

In order to make such a time-shared remote console system financially reasonable and viable to the participating groups, more than an information network must be offered. Consequently the information network should be just one of several files upon which the user could draw. Standard engineering and mathematical routines should also be made available. The user should be able to write, debug, and execute his own programs as in any time-shared online computer system.

### Management Report Generator

A final requirement of the system should be a series of programs and data files designated for the generation of reports about the system itself. Each user would have access to that portion of the management file pertaining to his own operations. The total file would be available to the organization operating the system. The file would provide data for management-oriented reports on system use, file sizes, and effectiveness of the information network.

### Summary of Recommendations for an Automatic System

The previous paragraphs describe two phases of automation applied to the Battery Index Activity. The first phase involves conversion of the existing file to machine-readable form and preparation of a set of programs with which to generate the current indexes from machine-readable input. The second phase involves a major system linking the users directly to the information file and the computer. The user would have the ability to perform searches within an information network. He would also be able to use the arithmetic and data manipulating power of the computer for engineering design problems as well as report generation.

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